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Engineering News-Record

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Finished Concrete Lining of Old Timber-Lined Railway Tunnel in California

Relining Pacific Coast Railroad Tunnels With Concrete

Proportioning Concrete by Voids in the Mortar

By Arthur N. Talbot

Steel Fabric in Concrete Road Costs 1c. a Yard to Place

By H. Eltinge Breed

Flood Control Reservoirs on the Minnesota River

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ENGINEERING NEWS-RECORD

DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

E. J. MEHREN, Editor

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Waste in Building

NO PANACEA can cure the disease of waste in the building industry revealed in Col. Thompson's report to the Committee on Elimination of Waste, which is abstracted in the news pages this week. The ills are too varied and too many for hope of immediate relief. In the principal troubles listed, however, there is a sharp difference between those which are due to individual ignorance or neglect and those which are fundamental, a result of evil conditions which will require a revolution to correct. All of the wastes due to inefficient management are readily remedied; they are in fact faults of the lower grade contractor and ones which a proper practice would not permit. The cure of this evil lies in emphatic and continued education. The wastes due to irregular employment, on the other hand, are not within the power of the individual to correct nor are the restrictive union working rules amenable to revision except as the result of a long campaign in which the labor leaders must have the most prominent part. With the Thompson report before it as an outline of conditions, American Engineering Council would do well to approach the Associated General Contractors with a view to joint action looking toward a systematic solution of the problem of building waste. It will be a long job which cannot be started too soon.

Claude

THE best map existing in the Oklahoma City water distribution system until recently was no better than the information in the brain of an old negro, Claude. Claude was a water boy in Oklahoma City when the city was young, less than thirty years ago. The other day Claude walked the streets east and west pausing at each intersection to tell the accompanying engineer what mains and valves existed under the ground. What he said was more dependable than the maps. The story of gates broken closed, principal mains with ungated hydrants on them and paved-over valves is told on another page. How many water departments depend on Claudes?

Public Works Estimates

THE wide gap between the original estimate for a public work and the actual cost can be no better illustrated than by the recital of the history of the proposed central heating, lighting, and power plant project for some of the public buildings in Washington. It will be remembered that five years ago a vigorous fight was prosecuted by the defenders of the "city beautiful" against the erection along the Potomac of a Government power plant which was to have chimneys disfiguring the skyline. In spite of this opposition, Congress authorized the construction of such a plant at a cost not to exceed $1,494,104, a sum which was increased a couple of years later—that is, in June, 1917—to $1,737,104. The first bid received on the work was for $1,698,500, which was in excess of the earlier appropriation and the plans were revised so that the bid accepted was $1,640,148. Work was started but foundation troubles led to its suspension in June, 1916. Based on the investigation of these troubles, revised plans were made in October, 1917, and the lowest bid for the additional work was $635,793. In June, 1918, the whole project was shut down to release labor and material for war purposes and the contractor paid $855,944 for the work which he had done. Recommendations now made to Congress state that, exclusive of the material delivered, worth somewhat over $200,000, the contract is 18 per cent completed. Considering from a financial standpoint, that is with the material added, it is 36 per cent completed. To proceed with the project and complete it the Secretary of the Treasury now reports would cost $4,000,000. This brief résumé is not given in criticism of any one connected with the project, but merely to show how a typical history of a public engineering project may read.

Railroad Tunnel Lining

REPLACING the timber lining with concrete in western railroad tunnels is as logical a procedure now as was the use of timber lining when the roads were built. Much the same reasoning applies as in the early use of a timber trestle which is replaced by a fill or a more permanent structure as soon as earnings warrant or as soon as maintenance of the original structure becomes excessive. However, a tunnel involves uncertainties that complicate the situation more than would be likely with any surface structure and it will be many years before all the old timber linings will be replaced with concrete. Some of the considerations involved and construction methods that have been applied on western railroads are reviewed in the article on another page. On lines where the locomotives burn oil, as is now the case on most Pacific Coast roads, and with concrete lined portals to protect the timbering from fires of external origin, the two most serious dangers in timber-lined tunnels are derailment and the loss of the arch. The latter represents not only expense to the railroad company but may mean prolonged blockade of the line. Derailed cars are almost sure to strike and catch on the plumb posts, wedge the cars across the tunnel and, if the overlying material happens to be heavy, may let down the arch. Wrecks of this sort catching on fire and burning the timber lining in both directions from the damaged section have blockaded main line railroads for weeks at a time because, in addition to clearing out the jammed equipment, it is necessary to open up the tunnel and restore the roof support. The hard, smooth surface of a concrete lining, on the other hand, prevents derailed equipment from damaging the tunnel or endangering the arch. While there are some notable exceptions, the tendency is strongly toward concrete lining on all permanent construction.

Cement and Aggregates

ELSEWHERE in this issue figures are given showing that for the first six months of 1921 the shipments of cement were 98 per cent of the shipments for the same period of 1920, and those of stone, sand and gravel 87 per cent. This seems a remarkable fact in view of the belief generally voiced that 1921 is a particularly lean construction year. It is true that so far this year roadbuilding has had one of the greatest periods of activity in its history. Yet highway work calls normally for about 25 per cent of the cement production. This year the per cent will undoubtedly be higher. Between 40 and 50 per cent of the cement goes to agricultural uses, and the balance to miscellaneous construction. Since the cement industry is in good shape it is natural that the aggregate producers are doing a good business. How is it then, if the construction industry is suffering so badly through inactivity, that the production and shipments of construction materials are so near to normal! Can it not be said again that we must be doing much more construction work than is popularly believed?

Conditions Reflected in Prices

IN CONNECTION with the foregoing it can be seen from present and past price quotations of cement and aggregates that business with these industries has been good. While a price war is being waged among steel manufacturers, operating on a 25 per cent production in the endeavor to stimulate buying, the price of structural shapes in the New York market has dropped to within 40 per cent of the average 1913 price. No such reduction has come in either cement, sand, stone or gravel. All these materials are double what they were in 1913. It is quite apparent that cement and aggregate producers do not have to enter into any price-cutting competition in order to stimulate business.

Railroad Engineers in Professional Class

ENGINEERS, whether or not they work for the railroads, should be interested in the Interstate Commerce Commission "Rules Governing the Classification of Steam Railway Employees and Reports of Their Service and Compensation," prepared by the U. S. Railroad Labor Board under the direction of J. L. Jacobs, industrial engineer, Chicago. Engineers have now a classification of their own. They are officially given professional status since they are listed under the "professional service" class along with three other groups, chemists, lawyers and architects. The order went into effect July 1, and the railroads are now revamping their classifications in accordance with the new rules. Engineers should see to it that they are properly placed. It will be much easier to get proper allocation now than a year from now.

Road Research

HIGHWAY research received a new impetus this week with the announcement by Engineering Foundation of the National Research Council's plans for the work of its advisory board and the selection of Prof. W. K. Hatt as director of future activities in this highly important field. This board, it should be explained, is not to function as an agency of investigation and experimentation, but rather as a means of assisting existing organizations in determining upon a national program of highway research, co-ordinating these activities, appointing committees for specific problems and, in fact, serving as a clearing-house for research information regarding roads. The time is ripe for a movement of this sort and the board takes a broad-gage view of the scope of its work in stating that the field will include economics, design construction and administration. In announcing its program the Engineering Foundation has made it known that "there is abundant money available for the research work itself." This news is reassuring. It frequently happens that the soundest kind of argument can be made in support of a program of experimentation such as that outlined for the highway research work. The trouble in the past has generally been, not in formulating a program, but in financing it.

Engineering Society Movements in Great Britain

IN WRITING from England last year the editor of *Engineering News-Record* indicated that engineering society movements in the United States were being closely paralleled by those of Great Britain. The young men are organizing on their own account; in the old societies a long period of conservatism is giving way to policies of expansion. Recently our English correspondent has summed up the situation for us as regards the Institution of Civil Engineers. His picture is a counterpart of that which we find in our own society of civil engineers. Says our correspondent:

"There is considerable controversy among members of the Institution of Civil Engineers regarding its organization and functions and the part it will play in the future in the engineering world of Britain. Several members have complained of the impending policy of decentralization evidenced by the formation of local bodies of members of the society, due to the demand of provincial members for a larger share in the facilities offered by the institution. Among the younger members there is claim for a larger share in the administration of the body, and also for more facilities for their own advancement in the science of civil engineering. While many of the older members are quite satisfied with the conduct of the institution, many others maintain that it needs bringing up to date so as to conform with modern ideas and tendencies. For instance, many students and associate members maintain that the institution shou'd assist its members in finding employment, that is to say, to establish an employment bureau on the lines adopted by other scientific bodies. Some go as far as to say that no engineer should be appointed who is not approved by the institution. Thus the society would take upon itself the functions of a trade union. This view is interesting especially as there is a strong movement afoot to promote a bill in Parliament to restrict the profession to qualified engineers. Such a bill if passed would probably lead to other developments; for instance, the establishment of a code of ethics and scales for remuneration. The adoption of such principles would go far toward establishing definite standards of education, both technical and practical, besides protecting the public from unqualified engineers. It is also felt that the institution might promote social and educational activities not only in London but in the great provincial centers."

All of which is but further evidence of the existence in England of the same fundamental conditions in the engineering profession that obtain here.

A Nation-Wide Highway Census

IN SPITE of the fact that roadbuilding has developed into the nation's greatest engineering activity, the fundamental data available regarding its extent and cost are far from complete. Many of the states, of course, have adequate records of their highway work, but from the national standpoint an all-inclusive summary of the situation does not exist. Any adequate picture of the status of road construction and finance must include, not only federal-aid, state and county work, but also the extensive paving operations within the limits of incorporated cities and towns. Lack of centralization in the administration, by states and lesser governmental units, of the various classes of highway and street improvement, has rendered difficult the task of a nation-wide survey. This deficiency the U. S. Bureau of Public Roads proposes to remedy by a country-wide census of highway mileage and funds, as outlined by Mr. Allen in this issue. Without such data as it is now planned to collect annually, highway work cannot be administered on the sound business basis which its future success demands. In practically all of our basic industries—steel manufacture, for example—the need for accurate statistical information regarding raw materials, production, unfilled orders, etc., as an index of fundamental current conditions, was long ago recognized and machinery developed for its periodic collection and compilation. The same procedure will be a great boon to the highway field. The gathering of these statistics is not a one-man job. The success of the effort depends upon widespread co-operation in which states, counties, townships, road organizations, and individuals must share. The load is too great to be borne by a few. The tremendous value of the results to be secured, however, justifies a prompt and accurate reply from all sections of the country to the federal government's questionnaire. In addition to its main object, one of the great auxiliary benefits to accrue from such a census is, obviously, the development of a uniform system of reporting road construction receipts and expenditures.

The Void Theory Revived

FERET, the French engineer, builded probably better than he knew when thirty years ago he published his famous void theory of mortar strength. Few contractors or engineers today are familiar with his paper, but every one of them when he specifies a 1:2:4 or 1:3:6 concrete is following Feret's deduction that void filling requires about twice as much stone as sand. Four or five years ago, several different investigators working mainly in this country commenced to throw some doubt on the void theory and though there were many engineers who continued to plead that proper proportioning requires that the cement paste just fill the voids in the sand and the mortar just fill the voids in the stone, tests showed that it was impossible completely to fill such voids in field concrete, even were it possible accurately to determine the voids in the aggregate in the condition it is when it is mixed in concrete. Consequently, proportioning theories began to look toward other properties of the aggregate—its linear and surface dimensions, for instance—and toward the effect of the amount of water which so obviously controls strength. To those workers in concrete who have been somewhat confused with the multitude of testimony and the contradictions in tests in these new theories of concrete proportioning, the return to the void principles advocated by Professor Talbot in his A. S. T. M. paper abstracted in this issue of *Engineering News-Record* will be most refreshing.

Although Prof. Talbot acknowledges his indebtedness to the earlier void theory and particularly to Feret, it will be clearly understood by reading the paper that he is working on some quite new lines. The early theories held that every void in the sand should be filled with cement paste and every void in the stone with the mortar. The bulking effect of wet sand was known and measured, but not quantitatively appraised in proportioning the concrete. Feret's tests, furthermore, applied practically only to mortar. Talbot goes further. His tests establish that concrete strength is inversely proportional to concrete voids, which he says is the same, quantitatively though not proportionately, as mortar voids, for in most practical concrete the mortar fills all the stone voids. He then proceeds to establish exact values for the variation in mortar voids for any given aggregate under varying conditions of water content and cement-aggregate ratio. He contends that the concrete strength-voids ratio is consistent regardless of grading, and that therefore all that is necessary in correct proportioning is to establish the mortar voids conditions of the aggregate under investigation and to fix the amount to be used in the concrete mixture of desired strength from a comparison with the standard curves for voids-strength relations. In other words, the analysis is based on mortar voids and not on aggregate voids as in earlier void theories.

Obviously this theory, as all other theories of proportioning, rests on tests. Professor Talbot has made a great number of such tests, but has a great many more under way and is, therefore, not insistent on the truth of his theory until he has had more confirmation. It should be stated, incidentally, that other investigators claim that tests do not always show density to be a measure of strength, so that the contradiction between tests is not yet fully composed.

It has been noted that although the Talbot theory admits the fact that the cement paste will not completely fill the voids in the fine aggregate, it is based on the principle that the mortar does completely fill the coarse aggregate voids. In his paper Professor Talbot says that the tests made and examined so far seem to confirm this contention within 1 or 2 per cent variation, which can be readily taken care of in his formulas for designing proportions. It would seem, however, that this particular feature of the studies would need considerable confirmatory tests for field placed concrete. Any one who has seen apparently well-settled concrete drop an inch or two in the form under the application of air hammers outside, wonders if possibly there are not in most field concrete voids not entirely accounted for by the failure of the cement paste to fill the sand.

A final remark regarding this and other apparently complex theories of proportioning may be worth while. The theories seem to be unduly elaborate and complicated to the man who has been in the habit of mixing 1:2:4 concrete, but the fact should not be overlooked that all of the elaboration and all of the complications are taken care of at one time by a few men working in a laboratory or an office, and that the field man who puts in the concrete need have no more difficulty in putting in a 1:1.96:3.52 concrete—provided that proportion has been established by some other engineer—than he would have in putting in his familiar 1:2:4 mix.

Relining Pacific Coast Railroad Tunnels With Concrete

Timber Put In When the Roads Were Built Has Given Long Service, but Hazard and High Maintenance Lead to Substitution of Concrete—Methods Used on Various Roads

IN THE early days of railroad construction in the West, practically all tunnels were lined with timber. Concrete lining was most rare. Cement would have required a long haul, while excellent redwood or cedar timber was nearly always available near the site and in those days could be cut and placed for about $25 per thousand. These woods have long life and high fire-resistant qualities; a considerable amount of redwood timber recently taken from tunnels on the Northwestern Pacific R.R. where the section was being enlarged was found to be in excellent condition after being in place 35 years. This long life cannot ordinarily be expected where heavy material is traversed, and in fact, timber lining is now regarded as a constant hazard because, in addition to the fire danger, there is the possibility of distortion through movement of the earth strata or through destruction by derailed equipment.

FIGS. 1 AND 2. CONCRETE LINING WORK IN PROGRESS, TEHACHAPI TUNNEL 6
At right, finished concrete section, with adjustable steel beyond. At left, section ready for concreting, showing timbers still in place behind the reinforcing. Concrete pipe on the right is serving an adjoining section.

As traffic and competition increase, blockades become more serious and freight and passenger departments become anxious to see concrete lining substituted for timber. Fortunately, concrete has become comparatively less expensive. Hence, in the extensive relining which has been done in recent years, for the most part concrete is being substituted for the timber.

On the Southern Pacific system, timber tunnel lining is being gradually replaced with concrete on lines where there is no question either as to permanence of location or continuation of a single-track line. Over the Tehachapi Mountains, for example, when the double-tracking project is carried out the new track will be built on a new location and the present single track (on 2.2 per cent grade) will be maintained for west or down-bound traffic. Yet all tunnels on the Tehachapi grade are being lined with concrete, and, in fact, the work is being given preference over that on other parts of the system. This is because of the greatly increased danger of blockades here, due to the fact that the maximum grades and sharpest curves on the 500 miles between Los Angeles and San Francisco occur in a 20-mile stretch on which there were, until recently, 17 timber-lined tunnels. Derailments due to worn and broken equipment are more likely to occur here than elsewhere on the line. Within recent years fires in the timber lining, and tunnel jams caused by derailed equipment, have several times blockaded traffic for days. Although this is only a single track, for 68 miles it constitutes the main line of both the Southern Pacific and the Santa Fe between San Francisco and Los Angeles, so that a tie-up very soon becomes a serious matter.

Lining at Ends Most Important—The danger of fire in timber lining is believed to come chiefly from sources outside the tunnel. For this reason, it is held, the danger is much reduced by concrete lining *at the portals*. In fact, lining the portals for a distance of about 100 ft. into the tunnel is now the accepted policy on the important tunnels of all western lines. The protection against fire afforded by portal lining was regarded as important enough in the case of the San Fernando tunnel to warrant the expense of a separate

camp at the west end in order that a 125-ft. length at that portal could be lined a year earlier than it would have been done by the concreting crew which was working through from the other end. Practically all the concrete lining placed by the Southern Pacific is reinforced. The Western Pacific, on the other hand, uses unreinforced lining, 18 to 24 in. thick, except where unusually bad conditions have to be met and a special section is designed. This company has designed various special types of lining. One of these has the crown of the arch well over to one side and ranges in thickness from 2 ft. at that point to a thickness of 4 ft. 6 in. at the bottom of the walls. In ordinary cases, however, the Western Pacific has found a uniform unreinforced section adequate, and no failures have been reported. The standard concrete lining of the Santa Fe system is unreinforced concrete 18 in. thick. This company early established the policy of putting permanent lining in its tunnels and all but two on the lines of this system west of Albuquerque were relined with concrete in the late nineties.

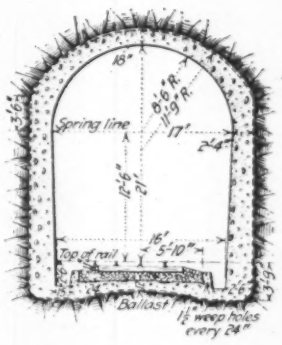


FIG. 3. TYPICAL CONCRETE LINED SECTION, WESTERN PACIFIC R.R.

Practice of Various Roads

Timber lining was used exclusively in the original construction of the Northwestern Pacific R.R., a line extending from San Francisco some 300 miles north. The first tunnels on this line were built about 37 years ago and very little timber renewal has been made to date. In fact, even allowing for replacement at much less than the average life of redwood, the renewal cost has been figured as less than the interest on concrete lining. Of course that does not take account of the decrease in hazard when concrete is used. In the district traversed by this line, however, the forest-fire menace is not considered great and the traffic is not sufficiently heavy to make very serious the hazard of blockades resulting from derailments in tunnels.

The common practice in the West is to estimate the life of redwood in sills, bulkheads, on bridges where the wood is in contact with the earth, etc., as three times the life of Douglas fir. Douglas fir is considerably stronger in cross-bending, and because wet-and-dry conditions in tunnel work are often not unfavorable, fir or pine is frequently used for tunnel posts, while redwood is used for footblocks and lagging, the latter usually in 3-in. thickness. How far the life of timber lining is affected by climatic conditions may be judged from the recent statement of the chief engineer of a railroad in the Northwest who said: "East of the Cascades we find that timber linings last from 12 to 15 years, while in the coast country it is often necessary to make renewals six years after date of construction."

TABULATION OF TUNNEL LINING ON WESTERN RAILROADS

Railroad	Total Tunnel Length in Ft.	Lineal Ft. Timber Lined	Lineal Ft. Concrete Lined	Percentage Concrete Lined	Lineal Ft. Not Lined
Western Pacific	45,588	26,964	8,370	18	10,253
Southern Pacific	153,484	112,221	32,536	21	8,727
Northwestern Pacific	34,900	30,074	1,542	4	3,283
Santa Fe (West of Albuquerque	10,049	1,760	8,289*	82	0
Great Northern R.R. (Western District)	40,329	7,364	26,289	65	6,676
Los Angeles & Salt Lake R.R.	9,198	8,869	0 0	0	329
O—W.R.R.& N. Co.	23,560	10,319	6,103	26	7,138
C. M. & St. P. R.R.	61,877	3,042	48,071	78	9,010
Sacramento & San Francisco	3,458	0	3,458**	100	0

*Includes 396 ft. tunnel lined with steel.
** Now being lined.

Tunnels through solid rock have been found to require comparatively little maintenance. In tunnel sections that did not require lining when the line was built, there has been little difficulty with water or with

In addition to the work on the Tehachapi, the Southern Pacific is concreting the San Fernando and Chatsworth tunnels (6,978 ft. and 7,238 ft. long respectively) in southern California as well as several tunnels on the Santa Cruz line. Moreover, on all divisions where tunnel maintenance gangs are worked, concrete lining is occasionally put in for short sections where heavy ground necessitates strengthening or replacing the timber lining.

Maintenance and Inspection—The cost of maintaining timber-lined tunnels through heavy material is always large, and increases as the timbers age. Some railroads keep tunnel maintenance crews in all divisions where there are timber-lined tunnels. On the San Fernando and Chatsworth tunnels maintenance crews averaging 18 men at each tunnel have lived at the portals and worked continually in one tunnel since shortly after the line was opened. Concrete lining will hold the tunnel arch in sections where the timbers are continually being crushed. For this reason, where a short timbered section becomes very difficult to hold, concrete lining is often put in for this short distance, leaving the remainder of the tunnel to be lined with concrete later, when financial conditions permit.

Decayed Footings

Where the timber is alternately wet and dry the decay is more rapid than otherwise. Ordinarily footings show decay first. Joints in the segments of the arch are also vital points. Inspectors looking for these conditions watch also for posts split by earth pressure. One experienced tunnel engineer states that it is his practice to note the deflection in the plumb posts as a basis on which to estimate the pressure of the overlying material.

With proper inspection methods it is believed that indications of practically every danger arising from weakened timbers can ordinarily be detected in time to have the timber replaced before the danger point is actually reached. Decayed plumb-post footings on the Los Angeles & Salt Lake R.R. have been repaired by putting in 8 x 12 and 12 x 12-in. sills and bracing these by 12 x 12-in. spacers put across from wall to wall just beneath the ties.

On this same railroad, as a means of reducing the danger of fires being started in the arch segments by cinders, the plan of nailing strips of corrugated iron to the top segment was tried. It was found, however, that the nails rusted out and allowed these metal strips to hang, thus becoming dangerous to trainmen riding on top of the cars. Tongue-and-grooved redwood was then used as a ceiling, covering all three of the segments. This is reported to be very satisfactory.

spalling rock. For example, a western railroad purchased a cement gun and equipment, expecting to use it for treating solid rock tunnels. That is, it was thought that this device would be useful for filling up crevices, stopping leakage and protecting the rock from weathering so that small pieces would not fall on the track. Frequent inspections, however, have failed to show the necessity for any such treatment and in the three years since the equipment was purchased it has never been used for this purpose

Reconstruction Methods

Various methods of relining railroad tunnels have been devised to suit traffic requirements or conditions of the old lining and the earth strata in the tunnel itself; witness the steel-lined tunnel, the precast concrete sections and the "coyote hole" method mentioned in the following. In the main, however, there are only two essential points on which lining methods differ: (1) Concrete is either cast around the timbers or they are first removed; (2) concrete is placed by gravity and by hand, or by the pneumatic process.

When timber lining is to be replaced with concrete, standard practice on the Southern Pacific system requires, in effect, the redriving of the tunnel because the timbers have to be set back far enough to allow the concrete to be poured inside the increased clearance thus secured. This setting the timbers back is the largest item in the cost of concrete lining. It requires all new timbers and the excavation of a large amount of material because the timber lining was put in for an 18 or 20-ft. clearance height while the specifications for concrete lined sections now call for 22 ft. clearance above rail. This means 4 to 6 ft. excavation in setting back the arch segments, beside the 2 ft. or more setback on the sides. In single-track tunnel the concrete lining is finished 16 ft. wide on tangents, with an increase in width on curves of 1 in. for each degree of curvature. The concreting can be done so much faster than the enlarging that the latter has to be laid out for several years in advance.

Methods of Placing Concrete

Setting the timbers back and then leaving them in place when concreting costs much more than the method of removing the timbers and replacing them with concrete, section by section. But the former method, in addition to giving an opportunity for increasing the clearance, affords assurance against cave-ins, of which there is more danger when employing the latter method. The cost of enlarging the section to Southern Pacific standards, using new timber and with labor and material prices as of April, 1921, is estimated to average about $85 per foot of tunnel; the cost of placing concrete lining is estimated as about $100 per foot. Because of the great volume of traffic handled on this system and the belief that competitive lines would get the through business in times of tieups, great importance is placed on avoiding any interruption of service.

With the comparatively light traffic over one of the competing roads, on the other hand, a 15-hr. main-line tunnel blockade could be absorbed in yards and sidings, and, by the use of extra equipment, satisfactorily cleared when the tunnel was open. Under these conditions it would be unnecessary for the latter company to refuse business in the time of such a blockade; in its tunnel-lining work, therefore, the concrete is being put in section by section, as fast as the timbers are taken out.

The pneumatic method of placing concrete lining has been made standard on the Southern Pacific system. This plan has the great advantage that it avoids the loss of time in taking out jumbo cars to allow trains to pass. This same railroad does its tunnel lining work with its own forces because the crews seem to require railroad experience in addition to experience in tunnel work in order that the lining may be done efficiently without obstructing traffic. Under the construction program followed on this system, the footings are poured first, and when they have had time to set, the walls and arch are placed. If an invert is required, footings and invert are poured as one operation.

On the Western Pacific concrete lining is still placed by hand in sections that cannot be reached by gravity chute from a high car; this is largely because their method of doing the work does not readily lend itself to the pneumatic system. The work is carried on in three stages, each stage being worked from one or more high-cars especially equipped for the operation to be performed.

Removing Timbers

The first stage consists of cutting out the timbers and, by means of crown-bars set back the necessary distance, protecting the exposed section of the tunnel for its full perimeter. As the concrete forms are used in 6-ft. sections, the timbering is removed for this length at each point where the tunnel is opened up. The crew removing timbers begins at the crown of the arch and goes entirely around the section, using timbers or blocking of whatever sort may be necessary to carry the thrust of the overlying earth to the timbers on each side of the section opened up. A second jumbo and crew puts the forms in place, while the concrete is poured by gravity from a third jumbo carrying mixer and chute. Gondola cars of rock and sand are usually spotted in the tunnel with the concrete jumbo car and these materials are shoveled from the gondola cars into hand buggies. The buggies are taken on runways up to the mixer, which is located at a level where it will just clear the arch crown. Concrete in the arch itself is shoveled into place by hand.

With this method, work can be advanced simultaneously at a number of different points, the crew and equipment being moved from place to place in accordance with a schedule planned so as to carry on the work most expeditiously for a given number of men.

Two tunnels recently enlarged on the Northwestern Pacific near Tiburon and San Rafael, respectively, were increased in height from 17 to about 22 ft. without any interruption to traffic. The work on the arch was carried on from jumbo cars which began at the portals and drove the arch of the tunnel anew, using the crown-bar method and putting in the new arch segments as they went. Crews working at track level followed the jumbos, setting back the plumb posts underneath the new crown bar. Excavated material was dumped from the jumbo car into six-yard dump cars on the track below which were handled by means of gasoline motor trucks fitted with flanged steel tires.

Work in Difficult Ground—In driving seven tunnels on the Willits-Eureka extension of the Northwestern Pacific in 1914, so much difficulty was experienced in holding the more difficult portions with timber lining

that a special concrete lining 30 in. thick was substituted. In the worst spots the points of attack were separated as widely as possible and only about 2 ft. was opened up at a time. Whatever the length opened up, the full section was excavated, forms set, and concrete poured in as close sequence as possible. The pouring ordinarily constituted about a day's work, so with four sections open, excavation would be going on at two, form building at one, and concreting at one. Two to four men could work together to best advantage in excavating the sections, dropping earth and timbers to the floor, where muckers kept the track clear.

On this work concrete was poured from a high platform supported by 10 x 14-in. posts, under which there was sufficient clearance for traffic. Posts were set along the wall so as to support the wall forms and were spaced on 8-ft. centers for the full length of the work. The wall forms consisted of 4 x 6-in. horizontal wales, 2 x 6-in. studding and 2 x 10-in. surface sheathing. The same sheathing was used on the arch, the segments for which were built up of two or three-ply 2 x 12 and 3 x 12 planks. Concrete was delivered on this high line in hand buggies over distances ranging up to 800 ft., and was dumped into the forms, shoveling being necessary only above the spring line.

Special Methods

A few examples of unusual lining methods are cited in the following:

At the west end of the San Fernando tunnel it was desired to place a short section of concrete lining as a small separate job. First, a 4 x 6-ft. hole was driven just above the crown of the arch, then, after the timbers had been moved back in the usual way and concrete forms placed inside them, concrete was taken into the hole on small push cars and dumped into the forms, thus placing the entire lined section without shoveling any of the concrete by hand. This method had the advantage that concrete was placed without interfering either with train schedules or continuous mixing.

The lining in a tunnel on the San Francisco & Sacramento R.R. is being built up for most of its length with precast reinforced slabs made in a casting yard near the portal, taken into the tunnel on flat cars and placed with a specially constructed derrick car.

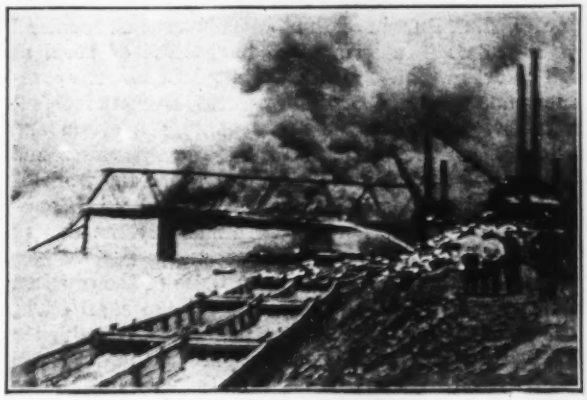
As a means of fire protection in a short Santa Fe tunnel in Johnston's Canyon, Ariz., rubble masonry was placed in between the timbers from the sills up to a height of 9 ft. Above that is a sheathing of ¼-in. steel plates. These plates are 30 in. wide and long enough so that a single plate reaches from the top of the rubble masonry around the curve to the center of the arch. The sides of each plate are attached to light angle irons, spaced 30 in. apart and bent to the same curve. These angles in turn are attached both at the crown and the springing line to a pair of 3 x 3 x ¼-in. angles fastened to the timbering.

Japanese Earthquake Investigation

The third number of Volume 9 of the Bulletin of the Imperial Earthquake Investigation Committee (Tokyo, Japan, March, 1921) contains papers by F. Omori on measurements of vibration of the 660-ft. wireless telegraph station tower at Haranomachi; of a 12-story brick tower and of 5-story pagodas; also a letter from Prof. C. Derleth, Jr., of the University of California on the vibration of the Sather tower at Berkeley.

The Burning of a Pittsburgh Bridge

The photographs reproduced here were taken during the progress of a fire which destroyed a steel truss bridge with a wooden floor across the Allegheny River at Pittsburgh, on July 8. The photographs were taken at intervals of from ten to fifteen minutes. A report of the fire is found in Engineering News-Record, July 14, p. 81.



Government to Make Road Survey

U. S. Bureau of Public Roads Plans Nationwide Census of Mileages, Revenues and Expenditures

By T. Warren Allen
Chief, Division of Control, U. S. Bureau of Public Roads, Washington, D. C.

THE U. S. Bureau of Public Roads has just launched a project to ascertain the total miles of rural as well as urban highways in the United States, the character and extent of their improvement, the cost incident to their construction and maintenance, the origin and disbursement of the funds for highway purposes and the details of administration under which the work of improving the nation's highways is carried out. Somewhat similar partial surveys were made by the Bureau in 1904, 1909 and 1914.

The present survey differs from those of the previous years in that it will not only embrace the rural roads, outside of incorporated villages and cities, but also the urban highways, including city streets, boulevards and alleys inside of all such incorporated areas having a population of 2,500 or more.

The need for such a survey is most urgent. Congress is studying the entire highway situation, the various states are building or planning extensive state road systems, while the counties and other local communities are voting large amounts of bonds or taxing themselves to the limit in order to raise funds for the betterments of their roads. Through this complex arrangement many kinds of taxes, bonds, assessments and fees are collected and appropriated for road purposes. But the origin of these funds, as well as the relation they bear to the value of the property taxed or the return from such investments, are as yet but vaguely known. Nor have we any definite data as to the improvements which should still be made nor the resources available for such work.

Object of Survey

The present survey aims to determine not only how much money we are spending on our roads and from what sources our road revenues are derived but also what results are secured from these expenditures. The investigations will therefore seek to determine the total road mileage in each county and incorporated community, the mileage improved with each of the several distinctive types of surfacing, the mileage under systematic maintenance as well as the extent to which the road mileage has been classified and the mileage embraced on such classified systems.

In order that we may know something as to whether the cost of our roads is distributed in accordance with the benefits derived, the investigation will include a survey of the various sources from which the funds are derived for construction of roads, of bridges and also for maintenance, together with the amount from each source. Data will also be collected as to the total investment in road machinery and equipment and the expenditures for its repair and maintenance. At present not even approximate information is available as to the amount invested by the states, counties, cities, towns and other communities in road building and maintenance plant, machinery and equipment, nor how much is annually expended for its maintenance and repair.

The Bureau of Public Roads believes that, with the total annual road and street expenditures rapidly approaching the billion dollar mark, it is time that the nation make a careful survey of the entire field of public highway activities in order that it may have at least as much accurate information in regard to the essential features of our highway work as a private organization would hold absolutely indispensable in the interest of common sense, efficiency and economy. The present plans provide not only for securing these data for this year but look forward to keeping this information up to date. An extra form will be left in the hands of each road official for recording and reporting the work and expenditures, etc., of next year.

District Offices to Aid Work

The bureau has now established, by virtue of its control over federal-aid projects throughout the nation, some thirteen federal district offices. It is proposed to make these offices the center for gathering the data from the states comprising each district.

To make this survey a success, the bureau feels that the co-operation of every unit of government doing road work is necessary and essential, and therefore requests the earnest assistance and co-operation of not only all road officials, but also of all associations, organizations or individuals that may have any information or data as to these particular lines of local highway activities.

Co-operation Sought

It is apparent that no single unit of government doing road work should be omitted in gathering these data. The federal agents recognize that in some of the smaller units of government there is no centralized control and no complete records. Here the local automobilist or others can give material assistance in checking up by speedometer readings the exact mileages of the various types of roads in the unit and the total road mileage.

The federal agents also point out that if future records are kept in accordance with the forms adopted for this survey all units of government will have adopted a uniform system for recording highway expenditures. Each succeeding year it will then be possible to gather the data of expenditures with ease and with some uniformity for comparative purposes. One extra form will be left with each highway official for making a return for 1922.

The results of the survey will be published for distribution when the compilation is completed. From it the large number of methods of road financing, control and operation of the varied highway programs of the nation will be clearly set forth and in detail.

Use of Lime in Water Purification

The amount of caustic lime used by water purification plants in the United States is estimated at 65,000 tons per year in a paper presented recently to the National Lime Association by C. Arthur Brown, chief engineer, Engineering Bureau-Water Purification, American Steel & Wire Co. This amount of lime is used by about 120 plants out of something like a thousand filter plants in the United States. Mr. Brown estimates that between 30 and 40 per cent of the water purification plants in the country might use lime advantageously. He notes also that the first complete municipal water softening plant in this country was designed by himself for Oberlin, Ohio, in 1902.

Steel Fabric in Concrete Road Costs 1c a Yard to Place

Pennsylvania Highway Constructed Under 1921 Specifications Requiring 56 Lb. of Metal per 100 Sq.Ft.

By H. Eltinge Breed
Consulting Engineer, New York City
(Copyright by H. Eltinge Breed)

This article is published in response to many inquiries received since the appearance of "Use of Steel Reinforcement for Concrete Pavements" in "Engineering News-Record" Dec. 23, 1920, p. 1231. Mr. Breed's study of the construction methods and costs discussed below, was made for the National Steel Fabric Co.

THE progress of road building is being so accelerated by the increasing demands of traffic, that the contractor has scarcely time to understand one scheme of operation before a new set of conditions is thrust upon him. Most recent of these is the 1921 requirement of the State of Pennsylvania for the use of steel fabric reinforcement, having an effective weight of 56 lb. per 100 sq.ft., an increase in weight over the 1920 specifications of 31 lb. Among various wild hazards about it, three questions persistently recur:

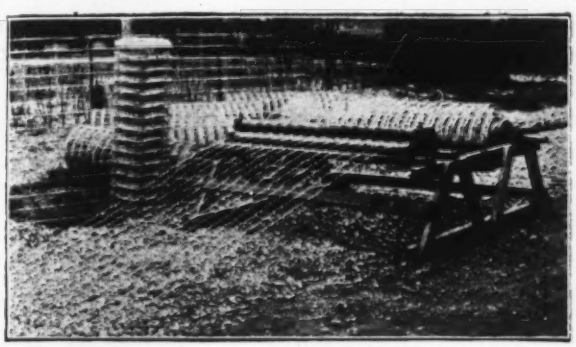


FIG. 1. DEVICE FOR STRAIGHTENING METAL FABRIC ROLLS

What is the best method of handling steel reinforcement? Does its use slow up the contractor's operations? How much does its placing cost?

To try to help answer these questions, the writer visited that road in Pennsylvania officially known as route 133, Upper Darby and Haverford townships. It is 12,077 ft. (2.28 miles) long, reinforced cement concrete type 6-, 8-, 6-in. section, 18 ft. wide, and carries 57 lb. of metal to the 100 sq.ft. The specifications require that the main members of the fabric reinforcement be placed transversely with the road to within 2 in. of the side forms; that the sheets be lapped 4 in., and placed in the slab 2 in. below the crown. These provisions for heavier reinforcement and its placing should afford additional safety to the slab, and, at a slight increase in initial cost, provide insurance against maintenance. Pennsylvania, as a state, is taking the lead in this direction.

The contract for this road was let Feb. 18, 1921, to the low bidder, Vincenzo Di Francesco, of Llanerch, Pa., for $118,429. The division engineer in charge is Mr. Longstreet and the inspector is Harry Dwyer.

The main plant units are concrete paver, two stone crushers with elevators, screens and bins, one charging bin of 300 tons capacity (200 tons stone and 100 tons sand), 5-ton trucks for sand, cement and metal and 2-ton trucks with hand hoists on aggregates divided to carry two batches. Brief observation indicates to some extent the efficiency with which a job is running, but the real test is the day-in, day-out performance. On this job 6,400 lin.ft. of pavement were laid between April 21 and May 18. The daily record for the last ten days of that period was: 300 ft.; 261 ft. (7 hr.); 408 ft.; rain; 322 ft.; 336 ft.; 374 ft.; 397 ft.; 425 ft.; and 410 ft.—or an average of 358 ft. a day for the nine actual working days, or 132 cu.yd. of concrete for a working day of 11 hr. The contractor believes that he can improve upon this performance.

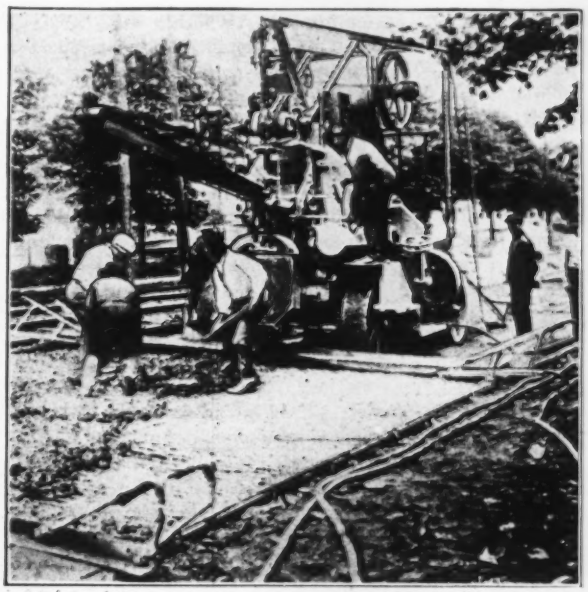


FIG. 2. TOP SURFACE CONCRETE BEING PLACED ON METAL FABRIC REINFORCEMENT

Cement and steel come on to the road from a railroad siding one mile from the job. The steel fabric is unloaded from the cars into motor trucks. A carload contains 130 rolls of National Steel Fabric Co.'s welded galvanized steel reinforcement. Each roll contains 125 ft. of fabric 58 in. wide and weighs 360 lb. There are approximately 8,420 sq.yd. to the carload. This material was unloaded and hauled 1½ miles by a truck with two men to load and unload in 10 hr. They took 13 rolls for a load. With the truck at $30 a day and labor at 35c. per hour, the cost for hauling and distributing is $0.0044 per square yard.

Straightening, measuring, cutting, and placing alongside takes from 45 to 54 min. per roll, *i.e.*, 3 men work from 15 to 18 min. per roll. Taking 54 min. as an average, with labor at 35c. per hour, this cost would be $0.0049 per square yard. One-half day's time for one of the four men behind the mixer to lay the metal fabric on the concrete would cost $2.50 for a $5-a-day man, thus bringing the cost of placing to an average of $0.0036 per square yard. Thus the total cost for unloading, hauling, straightening, measuring, cutting, placing alongside and placing in the work is $0.0129 a square yard. This is the high figure; the low figure would be $0.011 per square yard. We might justly eliminate the cost added for placing in the work because with the amount of concrete laid per day four men

are needed for spreading, etc., whether the fabric is used or not; then the cost would be under $0.01 a square yard. The contractor's cost for the first week of the work was $0.014 per square yard, which may be attributed to the newness of the work and the lack of familiarity with the operation.

The method of straightening the fabric is to place the straightening machine. furnished by the manufacturer of the reinforcing fabric, on the subgrade, as shown in Fig. 1. It is anchored by pins driven in front of the runners and bent over pins of ¾-in. steel driven into the grade at the rear of the runners, to keep the machine from tipping up. A shaft with two cones is placed in the center of a roll of fabric, which is placed on the machine in front of the straightening rolls, so as to unwind from the top. All tie wires but one are cut; then a tie wire is so placed as to hold the fabric while one circumference is unwrapped. The end of the fabric is pushed through the rolls and the last tie is cut. The trucks, on return trips to the aggregate bins, pull the fabric through the straightening rolls, the fabric coming out in a long, perfectly flat sheet, free from waves. Another roll is prepared at once. Between the pulling operations the men cut and distribute the fabric, set forms, etc. The use of the truck is not taken into the cost of the straightening operation because the time consumed is negligible—less than ½ min. more than ordinarily required to make the trip.

The operation of placing (Fig. 2) is simple. The steel fabric once unrolled is perfectly flat and in much better condition than when the reinforcement is shipped in sheets because these are bound to become bent and twisted out of shape and to need straightening before they can be laid. The concrete has been deposited on the grade, spread by the shovelers and evened off 2 in. below finished grade by the plow-handled template shown in the illustration. The welded steel fabric is then placed to overlap 4 in. and the concrete deposited over it roughly, spread and screeded by the angle-iron screed shown in the foreground. The striking off of the concrete for the steel fabric cannot be considered an additional cost because the number of men is the same when laying the same amount of concrete whether or not the fabric is used.

Colloidal Chemistry and Sewage

WHAT those handling sewage problems need from colloidal chemistry was noted as follows in a recent paper presented to the American Water Works Association by F. W. Mohlman, chemist, and Langdon Pearse, sanitary engineer, of the Sanitary District of Chicago:

(1) A standard definition of the limits of size of colloids in sewage. (2) A standard method for the determination of sewage colloids. (3) The study of the effect of the hydrogen-ion concentration on the removal of colloids, correlated with other determinations and observations which will prove the validity of such P_H determination. (4) Tests of the practical application of precipitants which have been found effective in laboratory experiments. (5) Investigation of the principle governing the retention of moisture by sewage sludge.

As yet, in the removal of colloids by tank treatment, but little has been accomplished in a practical way by settling alone or by the use of colloiders. Chemical precipitation by alkaline precipitants removes some of the colloidal matter, but adds so much to the bulk of the sludge that the process has not proved popular and is restricted in its present application to special cases.

Flood Control Reservoirs on the Minnesota River

Dams in Narrow Valley to Form Three Reservoirs with Gates for Manual Regulation of Level—Special Structures

RETARDING reservoirs in the valley of the Minnesota River, in Minnesota, constitute the only practicable means of flood protection for this valley, according to a recent report to the State Department of Drainage and Waters by Adolph F. Meyer, consulting engineer, Minneapolis, Minn. Manual operation of gates will be required, as the river is often out of its banks for several weeks, and automatic retarding basins are applicable only for flashy streams. Complete protection of all valley lands is not possible, as there

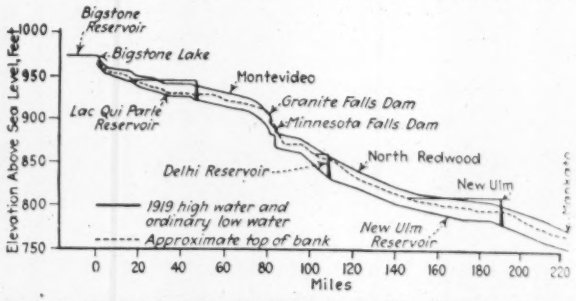


FIG. 1. PROFILE OF MINNESOTA RIVER AND PROPOSED FLOOD CONTROL RESERVOIRS

are no sites available for reservoirs on the tributary streams, so that some land must be sacrificed for reservoirs. Levee construction and channel straightening and enlargment are not applicable to this narrow valley, the area subject to overflow averaging only about a mile in width. Floods have been a source of trouble for the past thirty years, but the problem was not taken up actively until after the exceptionally destructive flood in the spring of 1919, which led to the engagement of Mr. Meyer.

Protection of the valley lands from the exceptionally large floods occurring only once in 25 years is not considered practically economical. Protection of most of the lands from frequent flooding, on the other hand, is concluded to be worth twice its cost, the best paying project being that which protects against all floods except those which may be expected to occur at intervals of ten to fifteen years. This purpose can be attained by reservoirs of moderate capacity, having high-water levels only a few feet above present flood levels. The area benefited will be three times that of the area depreciated by being within the reservoir sites. Further, the benefit per acre for the former will be greater, as an average, than the depreciation in the latter area.

Three large reservoirs are proposed, with a total storage capacity of 18,500 million cubic feet, as shown by the profile, Fig. 1. The first is Big Stone Lake, 4,000,000,000 cu.ft. between summer navigable stage at 965 ft. and ordinary high water at 972 ft. This dam would be near Ortonville and the Whetstone River would be diverted into the reservoir. The second reservoir, with dam near Montevideo, is at Lac qui Parle and Marsh Lake, with 9,000,000,000 cu.ft. capacity below El. 945; both the Chippewa River and the Lac qui Parle River would be diverted into this reservoir. The third site, with dam at New Ulm, is the valley above

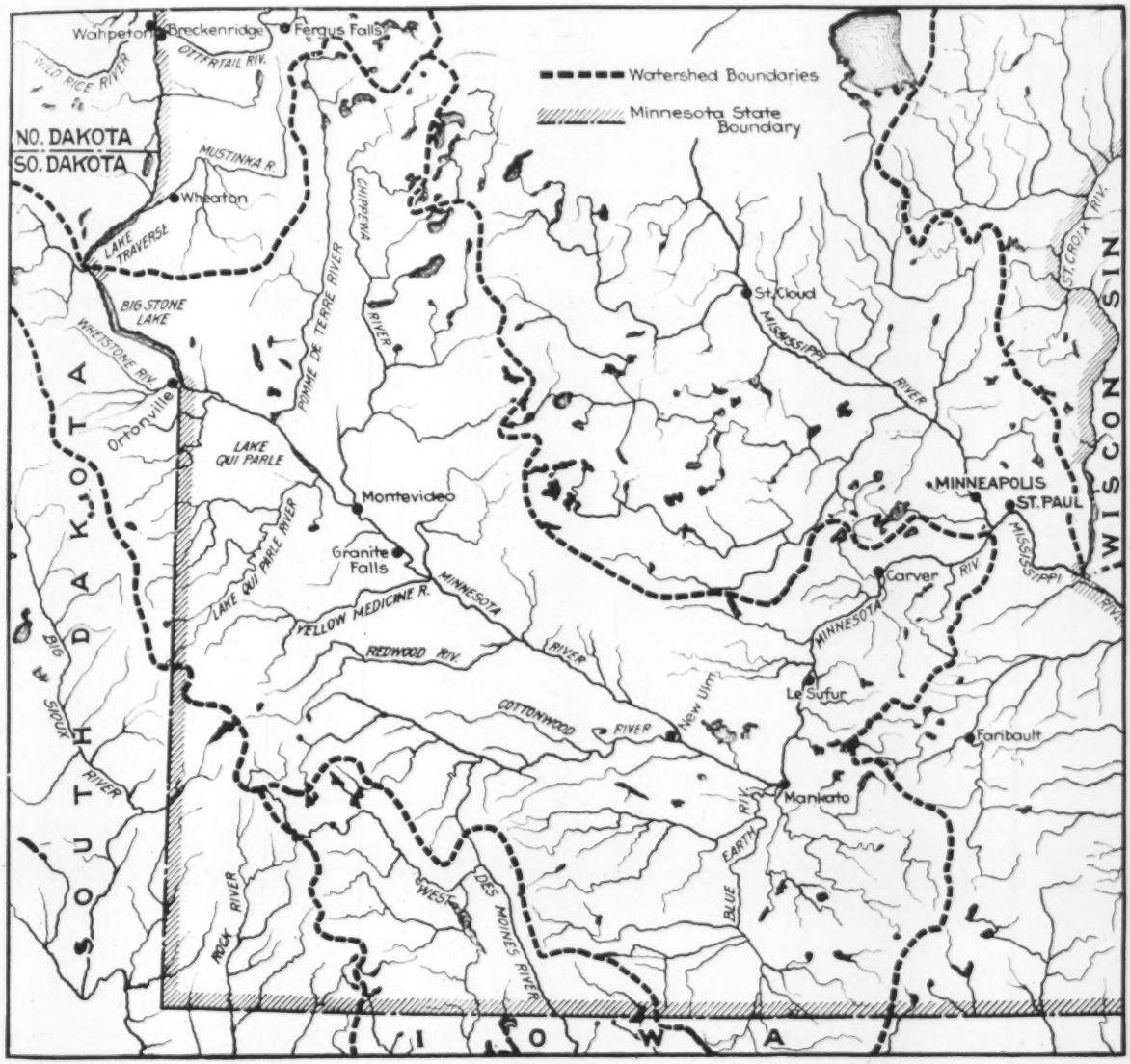


FIG. 2. DRAINAGE AREAS OF MINNESOTA RIVER AND ITS TRIBUTARIES

the mouth of the Cottonwood River, with a capacity of 5,500,000,000 cu.ft. below El. 910. A water power dam at Delhi is practicable, but it is considered doubtful whether the benefit to be derived from enlarging this project into a flood prevention reservoir would warrant the cost. For successful results, Mr. Meyer says the three reservoirs must be planned and operated as a single system for flood prevention purposes and not for power or navigation.

For water power, the only specific provision is storage of about 1,000,000,000 cu.ft. in Big Stone Lake, but part of the 18,500,000,000 cu.ft. stored for flood prevention may prove of considerable incidental benefit to water power. The dams will be on glacial drift, except the one at Delhi and possibly that at New Ulm, but they will be low and of reasonable cost. They will not require large spillways, as the total storage capacity will be adequate during extreme floods. An approximate estimate of cost is $2,000,000, on the basis of present prices.

The drainage basin of the Minnesota River, shown in Fig. 2, contains about 16,600 sq.mi. It is mostly under cultivation but varies widely in topographical, soil and cultural conditions. In general, the tributaries entering from the north drain more gently undulating lands than those from the south, the latter being extremely flashy. The following is from the report:

> The general direction of flow of the main stream and its tributaries is the same as the path of most of the rain-producing storms that pass over this drainage basin. The largest and lowest tributary, the Blue Earth River, has a fan-shaped drainage area. This causes rapid and high concentration of run-off at the mouth of this stream at Mankato. This ordinarily undesirable circumstance, however, actually operates to reduce somewhat the flood crest of the Minnesota River at Mankato, the extreme flood flow from the Blue Earth River having usually passed Mankato before the flood waters from the upper tributaries arrive. In the same way, the flood crest of the Cottonwood, the third largest tributary, reaches the main stream before the flood waters from above Montevideo reach New Ulm. These effects are due to the natural retardation of the upper flood waters in Lac qui Parle and Marsh Lake, which more than counterbalances the undesirable movement of rainstorms downstream.

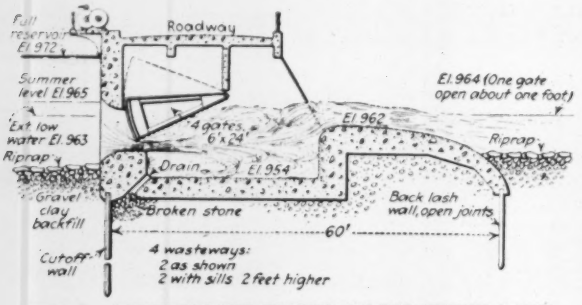


FIG. 3. CONTROLLING WORKS AT BIG STONE LAKE

Below Mankato the Minnesota River Valley, and particularly the lower portion, serves as a reservoir of considerable magnitude during most floods. The valley lands below Carver are so low that they are about as subject to floods from the Mississippi River as they are subject to floods from the Minnesota River. In this lower part of the valley the Minnesota River is virtually a lake formed by sandbars at the mouth and is gradually filling up with sediment. Although the proposed project will offer some protection from Minnesota River floods to the valley lands between Carver and the mouth of the river, it cannot protect these lands from floods caused by backwater from the Mississippi River when this stream reaches a flood stage at St. Paul.

FLOODS IN THE MINNESOTA RIVER AT MANKATO, MINN.

Flood		Discharge Cu.Ft. per Sec.	Above 15,000 Cu.Ft. per Sec. (Bank Full) Days	Volume Discharged Billion Cu.Ft.
1903	May 26 to June 4	38,700		9 54
1907	June		18	
1908	May	32,000	23	
1908	June 21 to July 15	43,800	25	25 05
1909	March	31,400	22	14 42
1916	March 20, April 29	30,200	23	16 81
1917	March 31, April 19		20	11 35
1919	March 15, April 28	30,500		19 85
1919	June 17, July 10	35,900	24	19 00

Many of the destructive floods are local in character. Flood-producing conditions seldom if ever occur simultaneously with equal intensity over such large and diverse areas as those included within the Minnesota River drainage basin. Early spring floods caused by the melting of accumulations of snow come nearest to being general through the entire valley. The most destructive floods, however, are those which occur during the crop season. Since they are largely due to flood flows from individual tributaries, these summer floods are normally much more severe in one part of the valley than in the remainder. If these floods are to be prevented by retarding the flood waters until the available channels can carry them away, then reservoirs must necessarily be located in various portions of the drainage basin.

Records of the greatest floods in the river are given in the accompanying table, the most severe in every respect being that of 1908. Although the flood of 1903 was second in height attained it was only seventh in volume and was of such short duration that it is not included in the seven floods which exceeded 18 days.

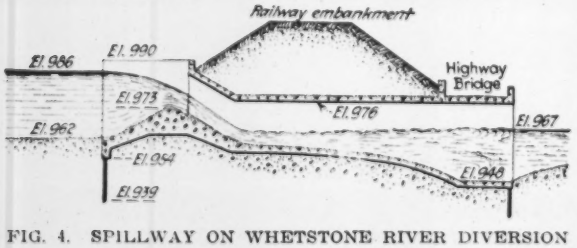


FIG. 4. SPILLWAY ON WHETSTONE RIVER DIVERSION

An important characteristic shown by the table is that the summer floods usually reach higher levels than the floods of early spring, but that there is relatively little difference between spring and summer floods in regard to duration or volume of water discharged.

Dams and Controlling Works

For the Big Stone Lake reservoir it is proposed to close to the south end of the lake with a low earth dam having controlling works where it crosses the channel of the Minnesota River, this channel being enlarged below the dam to a capacity of 400 sec.ft. Four sluiceways 6 x 24 ft. would be formed in a concrete structure of the design shown in Fig. 3, the discharge being controlled by Taintor gates. The maximum discharge capacity would be about 8,000 sec.ft. An unusual feature of the design is that the discharge from the gates

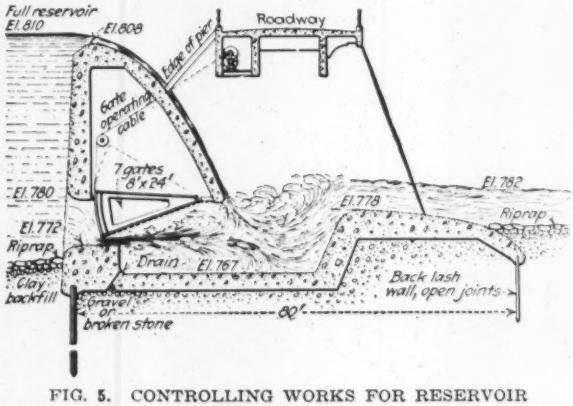


FIG. 5. CONTROLLING WORKS FOR RESERVOIR AT NEW ULM

enters a water chamber and flows upward and outward over the downstream edge, this chamber acting as a stilling pool to prevent erosion below the dam. It is proposed to supplement manual operation of the gates by automatic opening when the lake level reaches flood stage, this being effected by a small turbine having an open intake at flood level.

Diversion of the Whetstone River into Big Stone Lake by a new channel will be a necessary part of the work. On account of the large fall in the diversion channel, the flood water from this river is to be dropped over a spillway dam and sent under a railway embankment, at high velocity, through two culverts 15 x 30 ft. in section, with flaring mouths to slow up the water as it enters the reservoirs, as shown in Fig. 4. For the Lac qui Parle or Montevideo reservoir, only a low earth dam will be required, with new channels diverting the Lac qui Parle and Chippewa rivers into the reservoirs. Controlling works of a similar type to those at the upper reservoir would be used, giving a maximum discharge capacity of about 20,000 sec.ft. At the New Ulm reservoir the controlling works would be of the same general type, modified as shown in. Fig. 5, and having seven sluiceways 8 x 24 ft. to give a maximum discharge capacity of about 40,000 sec.ft.

General Principles of Regulation

On account of the rapidly increasing channel capacity from Big Stone Lake to Mankato, it is held that the size of flood protection reservoirs per square mile of tributary drainage area should increase upstream. The channel below Big Stone Lake, for example, has a

capacity only about 10 per cent that of the channel below Montevideo, even though the drainage area tributary to the lake is 20 per cent that of the Minnesota River at Montevideo. Further, it is held that such reservoirs should be relatively larger for small basins than for large ones, because the smaller the area the larger the rainfall and run-off, in inches depth over that area, which will occur with given frequency. Mr. Meyer explains that the project here proposed is in accord with the above principle.

Thus the New Ulm reservoir has a capacity of 5,500,000,000 cu.ft., or 128,000,000 cu.ft. per square mile, and its capacity is sufficient to store the equivalent of a sheet of water 0.55 in. deep over the tributary drainage basin between New Ulm and Montevideo. The Lac qui Parle reservoir, with a capacity of 9,000,000,000 cu.ft., or 180,000,000 cut. ft. per square mile, can store a sheet of water 0.77 in. deep over the tributary drainage basin between Montevideo and Big Stone Lake. Finally, the Big Stone Lake reservoir, with a capacity of 4,000,000,000 cu.ft., or 310,000,000 cu.ft. per square mile, can store the equivalent of a sheet of water 1.33 in. deep over the drainage basin which is tributary to it.

In regard to the control of these three reservoirs, within the limits of their capacity or exclusive of spillway discharge, Mr. Meyer explains that:

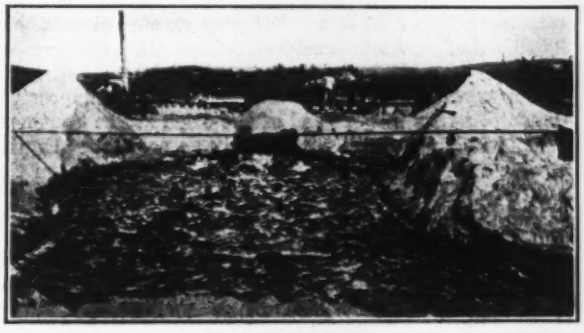
> In the operation of the proposed reservoirs, within the limit of their capacity, no water should be discharged from any one of them until it is full, or the stage in the reservoir next below it is falling, indicating that the inflow is less than the outflow. In general, this means that the upper reservoirs should be filled first and emptied last; or in other words, the storing of water should continue in the upper reservoirs until wasting has begun in the reservoir next below. During sudden freshets on the tributaries between any two reservoirs the wasting of the flood waters from the reservoir above should be suspended temporarily.

Systematic Maintenance for Fender Logs

Floating fender logs are used in the Port of Los Angeles to prevent the abrasion of fender piles and to distribute the shock of vessels bumping against them. The cost of maintaining these logs has been materially reduced by following a systematic program in inspection and upkeep. The method followed is summarized in the following: Logs selected for this purpose are preferably of cedar or occasionally of Douglas fir, not less than 2 ft. in diameter and 40 to 60 ft. long. The log is turned in a lathe at the mill so as to give a smooth surface free of bark and imperfections. (The saving in transportation due to reduced weight offsets about two-thirds the cost of turning the logs.) Holes are drilled near each end large enough for 3-in. pipes. A section of galvanized pipe slightly longer than the diameter of the log is placed in each of these holes and, after making lengthwise cuts in the projecting ends of the pipe with a hacksaw, the cut sections are bent back and driven into the log so as to hold the pipe in place. Through these pipes are threaded the galvanized iron chains which attach the log to the wharf and keep it right side up. The latter is accomplished by weighting the lower ends of the chains. As the tide range is 8 to 9 ft. chains of 13-ft. length are used. Before going into the water the log is thoroughly oiled with linseed oil or a vegetable oil substitute. The log is turned over at regular intervals so that sun and air may kill the marine growth and stop borer action on the submerged parts.

Santa Ana River Made to Cut New Outlet to the Sea

THE development of harbor facilities by Orange County at Newport Bay on the Southern California coast was not considered practicable until further damage by the Santa Ana River, which from time to time has deposited large amounts of silt in the bay, had been prevented. For example, in a 4½-month period a few years ago, the river left silt in the harbor estimated to total 900,000 cu.yd. Decision was therefore made to



INSHORE END SHOWING CULVERT UNDER RAILROAD

divert the stream directly and permanently into the ocean at a point about 5 miles upstream from its entrance to the harbor, at a point where the natural channel comes close to the shore line. An interesting feature of the work was that it was planned in such a way that only about 3 per cent of the total excavation required was made artificially, the river itself being made to do the remainder. This not only greatly decreased the cost of the work, but made it unnecessary to find means of disposal for the excavated material.

In order to provide a direct outlet to the sea at the desired point, it was necessary to cut a channel through a sandspit about 700 ft. wide, whose top was about 15 ft. above low water. To construct a channel of capacity adequate to provide for all floods that might be expected was estimated to require the removal of about 100,000 cu.yd. of earth. In addition to this, the tracks of the

OUTLET CUT BY FLOOD. NEW BRIDGE PIER IN FOREGROUND

Southern Pacific and Pacific Electric Railways, which traverse the spit, required to be taken over the new channel and raised about 5 ft. The two railways entered into a joint arrangement whereby a single bridge sufficed for both, and the harbor commission paid $20,000 toward the railroad reconstruction required. The harbor com-

mission agree to maintain the channel and its revetment, and the railroads agree to build and maintain the bridge.

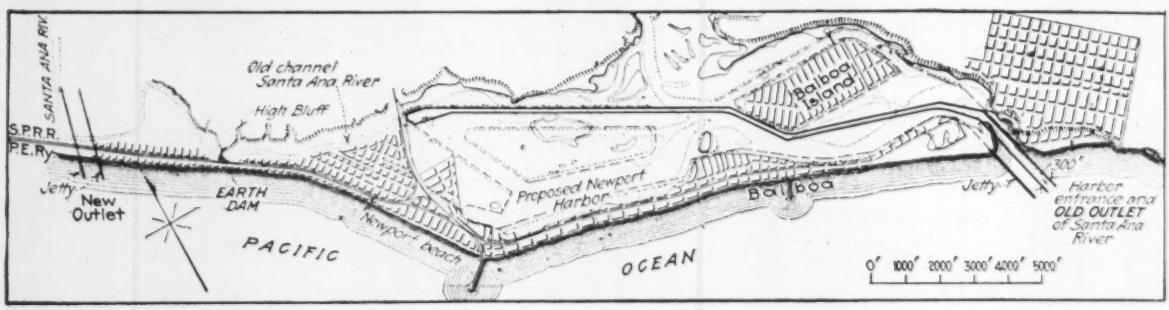
The first step in the diversion of the river, was of course the provision of a new and more direct outlet to the sea. Some time before the flood water season fresnos were used to cut a ditch through the sandspit at the point where the new outlet for the river was desired. This ditch was made 10 to 12 ft. wide at the bottom, with side slopes as steep as the material would stand, and was excavated to a level of about 4 ft. above mean low tide (as low as mules could work on account of ground water), except for a barrier at the ocean end of the ditch just high enough to exclude tide waters. A total excavation made in this way amounted to about 3,000 cu.yd. Any considerably greater amount of excavation would have made it necessary to find some means of disposing of the material. It was impossible to complete the inshore end of the ditch as the Southern Pacific Railroad (also used jointly as a shoo-fly by the Pacific Electric Railroad), was still in operation on the old tracks across the new channel.

The second step in the diversion of the river, was the construction of an earth fill dam in an advantageous

To prevent the closing up of the ocean end of this new river outlet, and to prevent its being moved along the shore line by wave action, rock jetties were built on both sides of the point where the stream now enters the ocean. The east and west jetties extend about 370 ft. and 670 ft. from the shore line respectively, and are 500 ft. apart. The direction of these jetties and their length, were determined from a careful study of local conditions. The jetties extend oceanward to a rock ledge at a depth of approximately 12 ft. below mean low water at their ends, and have a uniform elevation of 10 ft. above mean low water, with a top width of 10 ft. These jetties were built up as rubble rock mounds being built of large and small rip-rap and spalls in such proportions as to afford the maximum density with an armoring of large blocks of 6 to 8 tons on the outside. The rock of these jetties was extended northward to form a revetment of the banks of the channel, this revetment being carried down to approximately low tide level, in a trench previously excavated for the same.

In commenting on the capacity of the new outlet the engineer in charge states: "The present channel is realized to be inadequate to handle a major flood without enlargement but the results already secured with a moderate run-off, have shown that when such a major flood occurs, it will not only take the course desired, but that it will complete the excavation between the levees."

The work has been designed and carried out under the direction of Leeds and Barnard, consulting engineers, Los Angeles.



OLD AND NEW OUTLETS OF SANTA ANA RIVER IN CALIFORNIA

location between the new river mouth and the bay where a high bluff near the channel made only a short dam necessary. Though this dam will be a permanent structure, it will have only slack water against it, and is only about 300 ft. long with a height of 14 ft. where it crosses the deepest part of the channel. It was easily consructed at low cost with material scraped into place from the hillside nearby.

When the run-off from the first storm of the season came, the new bridge had not been completed, and the old Southern Pacific tracks across the new channel (on solid fill) were still in use. There was therefore, no available outlet, and the water pounding up against the dam and the railroad embankment, rose rapidly until within about 5 ft. of the top of the dam. The railroad hurriedly constructed a 3 x 5 ft. culvert under their track, from the river into the new channel above mentioned. As the storm had ceased, this culvert proved adequate to prevent further rise of the impounded water, and gradually drained off the accumulation.

The flood waters discharging through this culvert under a head of about 2 ft. rapidly cut the channel to the required depth and width, and carried into the ocean all material which caved into the flood waters, as the cross-section of the channel was rapidly enlarged by the stream. As finally excavated by the flood, the channel now has an average bottom with of about 50 ft. The channel is about 600 ft. long from mean low tide level at the ocean end to the river bank on the land side of the sandspit.

Illinois Commerce Commission Act

The Illinois act of 1921 creating the Illinois Commerce Commission is now in force and supersedes the former Public Utilities Act. One of the most important changes effected by the new law is the so-called "home rule" provision, under which the voters of a municipality may, by a majority vote, remove their local utilities from state control to the control of the city council or commission, subject to appeal from local decisions to the Illinois Commerce Commission. Any appeal from the orders of the commission shall be taken to the circuit court of the county in which the principal offices of the utility are located. The old law provided that appeals should be taken to the circuit court of Sangamon County, in which the capital city—Springfield—is located. The new law increases the number of commissioners from five to seven besides providing for eight assistant commissioners. The new law specifically exempts from civil service all employees except stenographers, and gives the governor power to appoint members of the engineering, accounting and rate staffs of the commission.

Building Column Fire Resistance Shown by Test—II

By R. E. Wilson
Engineer, Associated Factory Mutual Fire Insurance Co., Boston, Mass.

Conclusion of article pp. 106-110, of issue July 21, 1921

3. *Limestone or Limestone Gravel.* Concrete in which these materials are used for coarse aggregate gives by far the best results. No spalling and very little cracking occurred during the tests. All of the 4-in. limestone protections withstood the 8-hr. test and while still exposed to fire sustained ultimate loads of about three times the working load. To obtain the full value of this kind of protection the material should be clean and should not contain more than 5 to 10 per cent of clayey impurities nor more than 10 per cent of free silica.

(Tests subsequently conducted at the Pittsburgh Laboratories of the Bureau of Standards indicate that the fire-resistive properties of coverings made of siliceous gravel concrete can be appreciably increased by placing a reinforcement of expanded metal lath in the concrete. This procedure may sometimes be necessary where it is impracticable to use other kinds of aggregates.)

The sand used with the various coarse aggregates is of minor importance provided it meets the requirements of a good concrete sand, but, for best results the use of highly siliceous sands should be avoided in combination with limestone or limestone gravel.

The proportions of the concrete mixture appeared to affect the fire resistance to some extent where full protections were employed and for this reason a mixture not leaner than 1:6 is recommended.

The tests indicated no appreciable advantage in shape of covering, whether round or square. This fact is interesting because it has been somewhat commonly believed that the round covering is preferable due to corner cracking of the square coverings. Although this cracking occurred in the tests it did not apparently affect the results to any extent and where concrete subject to severe cracking and spalling was used no apparent retardation of this action was observed with the round covering.

Wire ties are recommended with all types of concrete protection and were found to be especially desirable where the concrete is subject to cracking and spalling as in the case of siliceous and sandstone aggregates. They are also needed to hold in place portions of concrete damaged by fire when subsequently subjected to the action of hose streams as was demonstrated in the fire and water tests.

A single covering of metal lath and plaster at least 1 in. thick may be used on steel columns to obtain a degree of fire resistance somewhat greater than that of unprotected timber or cast-iron columns, and two coverings, each at least ⅞ in. thick, were found to double the amount of resistance. This material, while having no load-carrying capacity, preserves its integrity very well under the action of both fire and hose streams. The mixture proportion used in the tests (1:$\frac{1}{10}$:2½ cement, hydrated lime, sand) is recommended, and though the details of application are unimportant the thickness of covering appreciably affected the results. For this reason the heaviest layer thicknesses which it is practicable to apply should be used. The effect of the air space between coverings, while not fully determined, is not believed to be of any appreciable value.

Tile Coverings—The amount of fire resistance afforded by single-layer coverings of 2-in., 3-in., or 4-in. hollow clay tile was found to be comparatively small, and even with medium hard semi-fire clay tile (which was the best kind employed in the tests) it is equivalent to only that of a single layer of metal lath and plaster. If it is desired to use tile and a greater amount of fire resistance is necessary, the tests showed that this can be obtained by placing concrete filling in the spaces between the column and tile after the tile is set. The use of tile without this filling is not recommended except in case of medium hard semi-fire clay, since with the other kinds of tile tested the cracking and spalling under fire allows the heat to reach the steel and the application of hose streams carries away large portions of the impaired covering. When concrete filling is used the column so filled is essentially a partly or fully protected column with an additional protection of tile. The concrete not only serves as a protection but also aids in holding the tile in place by adhesion and for this reason should always be placed after the tile is set.

Fire-Clay Resistance

Semi-fire clay of medium hardness has the best fire resistive properties, developing little cracking and spalling under fire. Hard-burned semi-fire clay, surface clay and shale follow in the order named, the latter cracking severely with spalling of outer shells early in the tests. The overall thickness of the tile appeared to have no appreciable influence on the results, and the mechanical strength was of no importance. This latter fact is of particular interest since some specifications based on mechanical strength would rule out tile of the better fire-resistive properties.

As a result of comparable tests, the use of metal ties in the horizontal joints is recommended as better than use of outside wire ties, and with tile subject to severe cracking and spalling the former method adds appreciably to the period of fire resistance. Outside plastering is not believed to be of much value, though this point was not determined for plastering which had aged over six weeks.

Brick and Gypsum—A covering of common clay brick laid flat with brick filling to give a nominal protection of 4 in. in thickness was found to afford a fire resistance equivalent to 2 in. of concrete with aggregates of trap, granite, sandstone or hard-coal cinders. The brick remained in place throughout the test though fluxing after 4½ hr. Brick laid on end and edge to give a 2-in. protection afforded only about one-quarter as great protection as brick laid flat, the large decrease being due to the instability of the units.

Solid gypsum block with gypsum filling and metal ties in the horizontal joints makes a very satisfactory covering material, the 2-in. blocks giving fire resistance periods equal to those obtained with the better kinds of tile with concrete filling and the 4-in. equivalent to a 3-in. protection of concrete made with trap, granite, sandstone or cinder aggregates. Failure is due to checking, shrinkage and disintegration of the blocks under fire with consequent loss of stability of the blocks, and not to normal heat transmission through the covering. In the latter respect gypsum showed itself to be by far the best insulating material. Its action under the application of hose streams in the fire and water tests was quite satisfactory, the strength of the blocks being well retained below the region of calcining.

Cast-Iron Columns—Unprotected cast-iron columns offer about twice as much resistance to fire as unpro-

tected structural steel columns and nearly as much as timber columns. No variation is caused by end restraint. The application of hose streams to heated columns, although inducing large permanent deflections, does not cause the columns to lose their load-carrying ability. Filling the interior with concrete increases the resistance offered to an amount approximately equal to that of timber columns. Protections of metal lath and plaster, concrete or hollow clay tile increase the fire resistance very materially, the action of the various coverings being similar to that with steel columns.

Lally Columns—The plain Lally column (concrete-filled steel pipe) was found to offer approximately the same amount of fire resistance as a cast-iron column. The reinforced Lally column has nearly twice this amount of resistance.

Timber and Concrete

Timber Columns—Timber columns with cast-iron cap and pintle or steel-plate cap bearings have fire resistance periods of 2½ to 3 times that of unprotected structural steel and slightly greater than that of unprotected cast-iron columns. The full fire resistance of the column itself is not developed with either type of cap, failure being due in every case to excessive heating of the wood at the upper bearing under the metal cap with resultant crushing and brooming of the fibers and ultimate cracking or slipping of the caps. This indicates that with a column cap of a material that will sufficiently protect the bearing surface, a timber column will withstand considerably longer fire exposure before failure and periods from two to three times as great could be expected. It is understood that fire tests being made by the National Lumber Manufacturers Association with a newly devised cap confirm this deduction.

Protections of a ½-in. layer of gypsum wall board and of a single 1-in. covering of cement plaster on metal lath which also covered the cap increased the fire-resistance periods from about 50 to 200 per cent respectively. In applying such coverings, however, consideration should be given to the danger from dry rot, and steps taken to prevent possibility of deterioration of the timber from this source.

Reinforced-Concrete Columns—The reinforced-concrete columns tested included both square and round vertically reinforced and round hooped reinforced types with steel covered by 2-in. integral protection. The concrete mixture was 1:6 with coarse aggregates of both trap rock and of limestone, and definite conclusions are made for these two materials only. The action of the concrete was quite similar to that of the same kinds of concrete as used for protections of steel columns, no spalling and but a very few fine cracks developing throughout the tests.

The fire resistance offered by the columns varies with the kind of aggregate used and is equivalent to that of the 4-in. concrete protections of similar aggregates on steel columns. The limestone has been given the full 8-hr. rating, as reinforced-concrete columns of this aggregate withstood the 8-hr. fire test and immediately sustained loads of two to three times the working load. In no case was there any apparent effect due to form of reinforcement or shape of column and neither the square nor round columns showed appreciable cracking.

In the fire-and-water test series concrete columns with siliceous gravel aggregate were included, and its action was similar to that observed in other tests of this material. Considerable crushing, cracking and spalling occurred with both square and round coverings of this material, and in one case the spiral hooping was exposed before the end of one hour.

Conclusion

In conclusion it may reasonably be stated that the test conditions are believed to have conformed quite generally with those which are obtained in good building practice. It is appreciated that the number of tests in certain groups was not sufficient to obtain the full range of variation. It is believed, however, that the reductions made in assigning fire resistance periods are sufficient to allow for all differences which may occur if reasonable care is taken to suitably identify materials and classify them in the proper groups and also to obtain a good grade of workmanship. The loading and bearing conditions obtained are considered as severe as those found in usual practice except that in some cases it may not be possible to duplicate the full bearing conditions of the concrete coverings. This advantage is, however, slight, as concrete will develop bond in a comparatively short length and whatever difference may occur is discounted by the reductions applied in assigning periods. In placing all coverings, however, they should be applied so as to obtain as full and continuous bearings as possible.

The fire exposure as determined by the standard time-temperature control curve which was employed is considered to be fully equal to, and probably greater than, that to which the building columns would be subjected in practice except where large quantities of highly combustible material are involved. The exposure was of high intensity and continuous throughout the test, a condition which would seldom be duplicated or exceeded even under most conflagration conditions.

With proper attention to the various features which have been noted above, it is believed that columns and coverings of the various types tested will be able to safely support their designed working loads throughout building fires of durations corresponding to their rated fire resistance periods and in the great majority of cases the columns so exposed will not have been permanently injured.

Fish Sales a Byproduct of a Drydock

According to the "Panama Canal Record" the large dry dock at Balboa has an unexpected profit in the way of fish. When the gates of the dock are opened for the docking of a vessel a number of fish usually swim in; and when the dock is pumped out they are left stranded on the floor, as only small ones can go through the grating over the pump intakes. Those which are edible are usually gathered by the men at the dock, and the inedible ones are thrown out. During a recent docking a school of fish swam in. When the dock was unwatered the floor was covered with them. In addition to those which the men took, and some 650 lb. taken by the Commissary Division, between 2 and 3 tons were dumped over the gates into the open sea. They were scooped into large buckets which were swung up and over the gates by a crane operating from the side wall of the dock. Most of them recovered and swam away. The Commissary Division realized 490 lb. of cleaned fish, which were sold as second-grade stock at 11c. a pound.

Proportioning Concrete By Voids in the Mortar

A Proposed Method of Estimating the Density and Strength of Concrete and of Proportioning the Materials by the Experimental and Analytical Consideration of the Voids in Mortar and Concrete

By Arthur N. Talbot

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Abstract of paper presented to Annual Meeting of American Society for Testing Materials, Asbury Park, N. J., June 22, 1921. The exact title of the original paper is as given in the subtitle above.

THE following paragraphs are given to show the purport of the paper, to indicate something of the methods of the tests and of the analysis, and to outline principles affecting the relation of the ingredients to the strength and density of the concrete.

1. For a given amount of cement per unit of volume of concrete in place (the quality of the cement and the quality and nature of the aggregate remaining the same, but the gradation of the aggregate varying), the greater strength is found in a concrete that has the smaller amount of voids and a lesser strength in one having the larger amount of voids (the voids being taken as the space occupied by the water and air). A definite relation exists between the amount of the voids and the strength of the concrete. The percentage of voids may, therefore, be taken as an index of the strength of the concrete.

2. For different amounts of cement and different gradations of the aggregate (the quality of the cement and the quality and nature of the aggregate remaining the same), the strength of the concrete varies with the ratio of the amount of cement used in a unit of volume of concrete to the voids in this volume (or the reciprocal of this ratio may be used), and the strength may be taken to be a function of this cement-voids ratio. A relation which is found to be still better is that between the strength and the ratio found by dividing the absolute volume of the cement by the sum of the voids in the concrete and the absolute volume of the cement, which may be termed the cement-space ratio.

3. If the amount of mixing water be varied in such a way as to change the bulk of the concrete, the strength will still be a function of the cement-voids ratio of the resulting concrete.

4. For the usual concrete mixtures the bulk of the coarse aggregate is less than the bulk of the concrete, or, in other words, the bulk of the mortar in a given volume of concrete is greater than the voids in the coarse aggregate alone (using the term mortar to include the cement, fine aggregate, and water). For such mixtures the voids in the concrete may then be considered to be made up of the water and air voids in the mortar. The density of the mortar for the consistency used in the concrete is, therefore, an important factor in determining the strength of the concrete.

5. If the amount of the water and air voids in the mix of mortar to be used in making the concrete is known, the voids in a resulting concrete may be calculated and the corresponding cement-voids ratio or cement-space ratio may be used as an index of the strength of the concrete.

6. By determining the voids in mortars made with a given fine aggregate but with varying proportions of cement, a characteristic mortar voids curve giving the relation between the mortar voids and the ratio of fine aggregate to cement may be made up for any given fine aggregate, and information will then be available on which to base calculations for voids and strength of concrete made with definite proportions of cement, fine aggregate, coarse aggregate, and water.

7. By determining the voids in various mortar mixes made with different fine aggregates of the same character and thus obtaining characteristic mortar voids curves of the given fine aggregate, comparisons may be made of the relative densities and probable resulting strengths of concretes made up with these mortars and with assumed volumes of coarse aggregate.

8. Knowing the characteristic mortar curve of a fine aggregate, (the general nature and quality of the aggregate otherwise being known), the proportions of the mix required to give a specified strength (including the amount of cement, fine aggregate and coarse aggregate) may be calculated, with a fair degree of accuracy.

9. The foregoing principles and methods are most readily applied by the use of the absolute volumes of the cement, fine aggregate, and coarse aggregate; but if the voids in the fine aggregate and in the coarse aggregate in a dry state or in the condition obtaining on the work are known, or the relation between the weights of the aggregate by bulk and by solid volume, the bulk of the fine aggregate and of the coarse aggregate required to make a unit of volume of concrete may be readily determined from the absolute volumes given by the calculations already referred to.

10. If the mixture is such that the voids in the aggregate are not fully filled by the mortar, the mortar voids will not be the measure of the voids in the concrete; but if the voids in the concrete are known, the ratio of the cement to the voids in the concrete will still be an indication of the strength of the concrete, except in the more extreme cases.

11. The amount of voids in a specified mix of mortar may be used to determine the acceptability of a given fine aggregate.

12. The method may be used to design the mix of the concrete whatever the amount of cement used and whatever the ratio of coarse aggregate to fine aggregate, though when

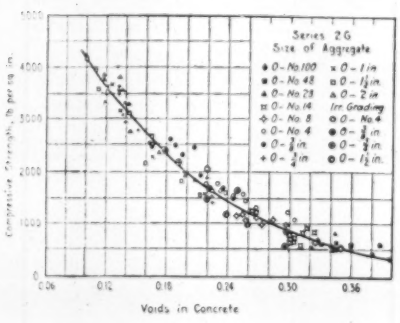


FIG. 1. RELATION BETWEEN VOIDS IN CONCRETE AND COMPRESSIVE STRENGTH

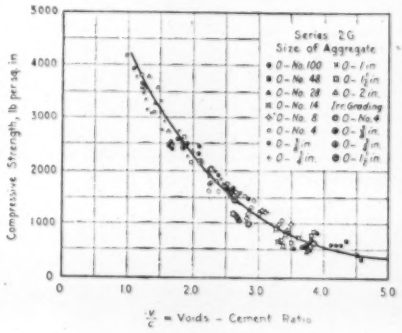


FIG. 2. RELATION BETWEEN VOIDS CEMENT RATIO AND COMPRESSIVE STRENGTH

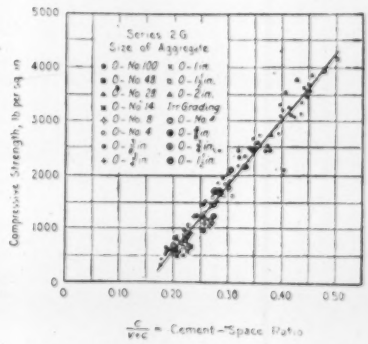


FIG. 3. RELATION BETWEEN CEMENT-SPACE RATIO AND COMPRESSIVE STRENGTH

the mortar does not fill the voids in the coarse aggregate this feature must have consideration.

13. In making the mortar test of a fine aggregate, the voids should be determined for increasing amounts of mixing water. The amount of water that gives the minimum volume of the mortar (greatest density and least voids) may be termed the basic water content. The characteristic mortar voids curve made up from values of the voids for minimum volume of mortar may be termed the basic characteristic mortar voids curve. The basic water content permits a very good consolidation of the particles of the mass when put into the mold; more water swells the mixture, as it also adds to the mobility of the mixture. For other water contents, giving the wetter consistencies, such as for example a 1.20 basic water content, characteristic mortar voids curves may be made up from the voids obtained with the specified water content ratios in the tests already made. If a larger amount of water than the basic water content is to be used in the concrete, the characteristic curve for that proportionate water content should be used in the calculations. Generally, for the consistencies used in concrete work, the water content will range from 1.10 to 1.40 times the basic water content.

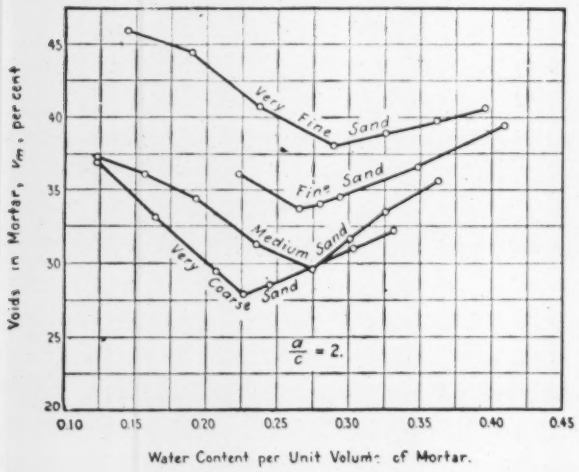


FIG. 4. RELATION OF VOIDS IN MORTARS TO WATER CONTENT FOR $a/c = 2$

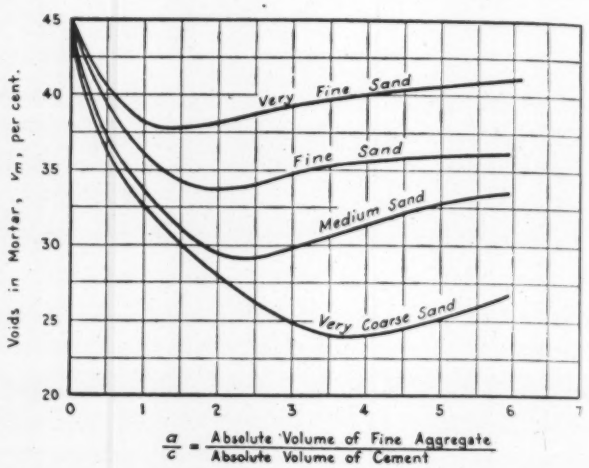


FIG. 5. CHARACTERISTIC MORTAR VOIDS CURVES AT BASIC WATER CONTENT

The foregoing principles have reference principally to the effect of gradation of particles and of the space in the concrete between particles upon the compressive strength of the concrete. Neither the structural strength of the aggregate nor the quality of surface which promotes adhesion (for which the word adhesibility may be coined) is taken into account; these may need separate consideration. The relations between strength of concrete and the amount of cement and voids in the concrete are of course subject to the variations inherent in fabricated materials. Their applicability is also affected by the errors of measurement involved in the processes of the tests.

Voids and Compressive Strength of Concrete

In Fig. 1 are plotted the results of tests made at the University of Illinois in 1919 the ordinates represent compressive strength at 28 days and the abscissas voids in the concrete. In these tests including what would be termed mortar mixtures ten groups of aggregates were used. The range in size of particle for the several groups by sieve sizes was 0—No. 48, 0—No. 28, etc., to 0—1, 0—1½ and 0—2 in. In all cases there was a regular gradation from fine to coarse according to an adopted equation, but each group included eight or ten gradations. At one end of a group the fine particles predominated, at the other end the excess of coarse particles gave a "coarse mix." The series included, in all, 88 of these regularly graded aggregates. In addition to these, 12 irregularly graded mixtures of fine and coarse aggregate were used. A single mixture with 0—No. 100 sand is included. The same proportion of cement by loose volume was used in all the specimens—one part of cement to 5 parts of mixed aggregate. Due to differences in the bulking of the mixture the amount of the cement in the resulting concrete varies somewhat (a result which is always present in concretes proportioned by loose volume), ranging from say 0.17 cu.ft. of cement by bulk per cubic foot of concrete for the finer mixtures of each maximum size of aggregate to 0.21 cu.ft. per cubic foot for the coarse mixtures of each size, or in terms of the absolute volume of the cement from 0.08 to 0.10 cu.ft. of cement per cubic foot of concrete. The concrete was all of a normal consistency, giving 0 to ¾ in. of slump for all the mixtures for which the slump test was found applicable and the same apparent degree of wetness for the very coarse mixtures. The results of all the very coarse mixtures are included in the points in Fig. 1—those in which the mortar part of the mixture does not fill the voids in the coarse aggregate and which are of less strength than the mixtures producing maximum density. A plotted point represents the average of three or four test specimens. It is to be noted that for a 1:5 concrete having 0.10 voids, the strength at 28 days was 4,000 lb. per square inch, for 0.35 voids the strength was only 500 lb. per square inch.

In Fig. 2 the same tests have been plotted in terms of the ratio of the voids in the concrete to the absolute volume of the cement used in a unit of volume of concrete. The points are seen to be more compactly placed. In Fig. 3 the same tests have been plotted in terms of the ratio of the absolute volume of the cement, c, in a unit of volume of concrete to the space around and about the particles of the aggregate (sum of the voids and the absolute volume of the cement, $v + c$). This ratio gives the proportoin of the space around and about the particles of the aggregate that is occupied by the cement and through which it is expected to act or be effective, and represents in a way the dilution of the cementing material.

Voids in Mortars

Tests of mortars show that, for any given proportion of cement to fine aggregate, the voids in the mortar vary with changes in the volume of mixing water used. The value of the voids and their change with additions of water will depend upon the gradation of the fine aggregate, each aggregate having its own individuality. Fig. 4 shows the voids in mortars made with four typical sands—very fine, medium and very coarse—for a ratio of fine aggregate to cement by absolute volumes, a/c, equal to 2. The water content is given in terms of the volume of the mortar; for example, 0.25 cu.ft. of water per cubic foot of mortar. For each of these sands, with additions of water the voids decrease to a minimum and then increase. The point of minimum voids (minimum volume of mortar) is definite and readily fixed;

it is here termed the point of basic mortar voids, and the amount of water used per unit of volume of mortar is termed the basic water content. The water content in wetter mixes may be expressed in terms of the basic water content; a 1.30 basic water content would mean that the amount of water used per unit of volume of the resulting mortar is 1.30 times that water content per unit of volume of mortar which gives the minimum volume of mortar—the swelling of the mortar through the addition of water thus being taken account of. It will be noted in Fig. 4 that fine sand gives higher mortar voids than coarse and that the basic water content also differs. Mortars at basic water content are fairly near to what is usually considered normal consistency, or a little dryer.

By making the mortar-voids test for several mixes (several values of a/c enough points may be determined to give the relation between voids in mortar and values of a/c for the given fine aggregate. The value of the voids at minimum motar volume (basic water content) has been taken from Fig. 4 and from similar diagrams for other mixes, and several such points were used in Fig. 5 for each of the four sands, giving what is termed the characteristic mortar voids curve at basic water content. In Fig. 6 characteristic mortar curves for the coarse and the fine sand are given at three water contents, the data having been taken from Fig. 4 and others like it.

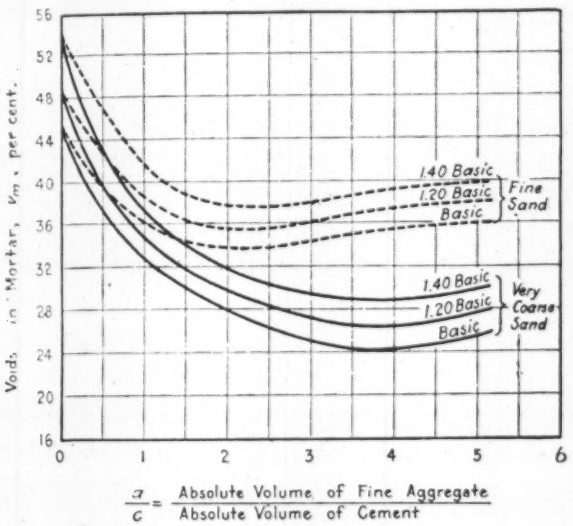


FIG. 6. CHARACTERISTIC MORTAR VOIDS CURVES AT THREE WATER CONTENTS

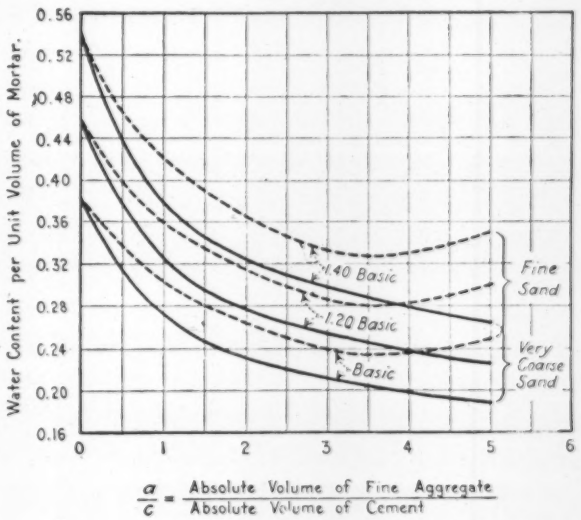


FIG. 7. WATER CONTENT FOR MORTARS WITH TWO SANDS

Several characteristics of such curves may be noted. For a given water content the curves for different sands converge to a single point at the left, which represents the voids in neat cement at the given consistency. Two sands may not be expected to have the point of minimum voids at the same mix. The characteristic curve of a coarse sand generally shows a rapid increase in voids as the richness of the mix is increased from $a/c = 2$; this property of a coarse sand will be found to tend to limit the advantages of the coarse sand in rich concrete mixes or where a well graded coarse aggregate is available. The relative increase in voids with the addition of more water is less for a fine sand than for a coarse sand.

For a given fine aggregate, the water content required for a unit of volume of mortar may be taken for a number of mixes from curves such as those shown in Fig. 4 and then plotted to make a diagram such as that in Fig. 7. The three curves for each sand indicate the water content required for a unit of volume of mortar for the three conditions, 1.00 basic water content, 1.20 basic water content, and 1.40 basic water content. This water content curve may be made up at the same time that the characteristic mortar curve of Fig. 6 is prepared. The values take into account the bulking of the mortar with the addition of water. The curves in Fig. 7 bring out the variation in water content for different mixes and different sands.

Knowing the void properties of the mortar the application to the concrete mixture may be made by analytical considerations. The following notation will be used:

a = absolute volume of fine aggregate in a unit of volume of freshly placed concrete;

b = absolute volume of coarse aggregate in a unit of volume of freshly placed concrete;

c = absolute volume of cement in a unit of volume of freshly placed concrete;

d = density or solidity ratio of the freshly placed concrete;

v_m = voids (air and water) in a unit of volume of the mortar or mixture of cement, fine aggregate and water as it exists in the concrete.

v = voids in a unit of volume of the concrete. This, of course, will be equal to $1 - d$.

It is evident that

$$a + b + c = d = 1 - v \qquad (1)$$

Since the mortar and the coarse aggregate together make up the unit of volume, it is also evident that

$$\frac{c + a}{1 - v_m} + b = 1 \qquad (2)$$

A third equation derived from Eqs. 1 and 2 will be found useful:

$$v = v_m(1 - b) \text{ or } b = 1 - \frac{v}{v_m} \qquad (3)$$

These equations give the relations necessary for determining the density of concrete; they may be used to check one another. It may be necessary to assume tentative values of one or more of the variables, and then modify the values so that Eqs. 1 and 2 will be consistent with each other. The characteristic mortar voids curve for the fine aggregate to be used, should be known in advance, though approximate values may be sufficient for certain purposes. Some of the conditions or cases to which the analysis may be made to apply are: a given value of c and a specified ratio of a to c; a specified ratio of b to a; specified values of b and c; and a specified value of v/c. In the examples which follow the value of v_m used is understood to have been taken from the characteristic curve of the particular fine aggregate that is to be used and for the ratio of a to c of the mortar mix, that curve being used which corresponds to the water content ratio giving the desired consistency. In case the ratio a/c is not known at the start a tentative value may be taken and a second calculation made with a revised value of v_m.

[One application of many in the original paper is as follows.]

Given c and its ratio to a. To find d and the strength of the concrete.—

Assume $c = 0.1$ and $a = 0.25$. This c corresponds closely to a 1:5 concrete mix and a to a not uncommon relation between cement and sand. Consider that for $a/c = 2.5$ the value of v_m is known to be 0.30.

Then $$\frac{0.1 + 0.25}{0.70} + b = 1 \therefore b = 0.50.$$

$$0.25 + 0.50 + 0.1 = d = 0.85.$$

The ratio $\frac{v}{c}$, then, is $\frac{0.15}{0.10} = 1.5$, and from a diagram such as Fig. 2, the strength of the concrete may be expected to be, say, about 3,000 lb. per sq.in.

[Other cases worked out in the paper are: given the voids ratio, find the amounts of aggregate and cement; to find the amount of cement required with different fine aggregates; given amounts of coarse aggregate and cement, to find the amount of fine aggregate and the density; given the amount of cement and the ratio of fine to coarse aggregate, find the amounts of aggregate and the density; given the water content curve for a mortar with a fine aggregate, find the water content for the concrete; find the effect of an increase in amount of mixing water upon the density of the concrete.—EDITOR.]

MORTAR VOIDS TEST DATA

Tests to determine mortar voids and the voids and strength of the corresponding concrete test specimens have been carried on at the University of Illinois. About thirty fine aggregates, including artificial mixtures, have been used. They include a variety of material. The results of the compression tests are not yet available. To show the variety and the individuality of the fine aggregates, the characteristic mortar voids curves of a number of these fine aggregates have been plotted in Fig. 8; these are given for minimum mortar volume or basic water content. The nature of the fine aggregates and the location or source of the supply are given in Table I, as well as the specific gravity, fineness modulus and surface modulus of the sample. Table II gives the sieve analysis of these fine-aggregates, the sieves used being Tyler standard sieves. It should be noted that in the concrete test specimens proportioned and made up from the data of voids of these characteristic mortar curves and by the analytical methods already described, the voids of the specimens checked fairly closely with the predetermined values.

TABLE I. FINE AGGREGATES OF FIG. 8

No.	Description	Specific Gravity	Fineness Modulus	Surface Modulus
0	Ottawa standard sand	2 65	2 99	12 6
1	Sand from Joliet, Ill., screened through fine sieve	2 76	0 92	60 8
5	Sand from shore of Lake Michigan	2 64	1 40	40 2
6	Limestone screenings from Milwaukee, Wis.	2 76	2 40	37 0
7	Chats from Joplin, Mo.	2 60	3 80	13 2
10	Dune sand from Gary, Ind.	2 68	1 00	51 6
11	Crushed slag from Chicago, Ill.	2 70	4 11	12 8
12	Crushed granite from Berlin, Wis.	2 61	3 41	23 5
13	Platte River "gravel" from Fremont, Neb.	2 63	3 23	19 9
14	Glass sand from Mapleton, Ia.	2 64	1 83	33 4
15	Crushed slag from Lorain, Ohio	2 64	3 70	17 9
16	Granulated slag from Buffington, Ind.	2 51	2 69	22 7
17	Sea sand from Atlantic City, N. J.	2 75	0 96	53 4
18	Sand from San Diego, Cal.	2 71	3 50	13 7
20	Washed sand from Elgin, Ill.	2 72	2 81	20 2
21	Sand from Medicine Hat, Canada	2 66	3 16	15 1
23	Sand from Greenup, Ill.	2 63	1 41	41 6
24	Sand from Attica, Ind.	2 69	3 34	16 6
36	Artificially graded sand between No. 28 to 4 sieves	2 69	3 70	8 7

OBSERVATIONS

Generally speaking, the greater the value of b (the absolute volume of the coarse aggregate), the greater the density of the concrete (as is shown by Eq. 3), up to the point where the voids in the coarse aggregate are not filled by the mortar. Further, the better the grading of the coarse aggregate, the less its voids and the greater the maximum value of b that can be used in a concrete. For the tests in Series 2G already referred to, well graded gravel was used, and the greatest density and greatest strength for ¼—1-in. coarse aggregate were obtained with $b = 0.59$; for ¼—1½-in., with $b = 0.65$; for ¼—2-in., with $b = 0.63$—larger values of b resulted in greater voids and smaller strength. The highest density obtained was 0.90. These high values of b give a very harsh coarse mix, not easily worked and not applicable in concrete work except under unusual conditions of placing and tamping. There is, of course, some lack of adjustment through the larger particles of the mortar getting between the particles of the coarser aggregate (a wedging action it is sometimes called), and the voids in the concrete may even be thereby increased somewhat over the analytical values.

TABLE II. SIEVE ANALYSIS OF FINE AGGREGATES

No.	Percentage by Weight Passing Each Sieve					
	100	48	28	14	8	4
0	0	0	1	100	0	0
1	34	74	99	100	0	0
5	1	60	99	100	0	0
6	23	37	52	67	84	98
7	3	9	20	32	57	100
10	6	95	99	100	0	0
11	5	9	16	25	45	89
12	15	21	28	39	61	96
13	3	19	42	57	72	88
14	3	32	93	99	100	0
15	9	15	24	34	55	93
16	7	15	37	76	98	99
17	9	95	100	0	0	0
18	1	7	24	48	75	94
20	2	12	51	71	86	98
21	1	5	32	61	79	92
23	7	54	99	100	0	0
24	4	10	25	51	78	97
36	0	0	0	50	80	100

For these reasons there must be a limiting value of the bulk of the coarse aggregate that may be put into a unit of volume of concrete; this may be 75 to 90 per cent of the volume of the resulting concrete, according to the gradation and shape of the coarse particles and the method of placing the concrete. A well graded gravel coarse aggregate may have 0.35 voids and a density or solidity ratio of 0.65. If the requisite mobility of the concrete may be obtained when the bulk of the coarse aggregate is 90 per cent of the volume of the concrete, the upper limit of b for this aggregate would then be 0.59. For an aggregate of fairly uniform size the voids may be 0.45 and the density 0.55; $b = 0.51$ would be the corresponding upper limit for this. A still smaller amount of the coarse aggregate will give a more easily worked concrete; the need for mobility or workability will influence the choice of the limiting value of b, the limit thus depending upon the nature of the work.

Tests to determine just what the limit of b should be for any given aggregate and any given working condition may readily be made. Well rounded pebbles will give a higher allowable value then elongated ones. The limit for broken stone may be expected to be lower than for gravel, the difference depending upon the angularity of the pieces. From this upper limit the value of b may, of course, range down to nothing. When the value of b used is less than the upper limit, differences in the grading of the coarse aggregate, of course, will not result in any change in the density of the concrete, provided the absolute volume of the coarse aggregate remains the same, and a coarse aggregate of uniform size will give the same density as one that is well graded.

For a given value of b the volume of the motar given by Eq. 2 is $1 - b$. The value of a (the absolute volume of the fine aggregate) that fits in with a given value of b will depend upon the absolute volume of the cement c and upon the mortar voids v_m. In general, the finer the sand the greater the mortar voids and the less the volume of the fine aggregate that would be used. It will be found, however, that the extent of the difference will depend upon the nature and shape of the characteristic mortar voids curve.

The data of the tests show that at minimum volume (basic water content) the voids in the mortar are not entirely filled with water, the proportion varying with the nature of the fine aggregate and the richness of the mix and ranging from 65 to 90 per cent or even somewhat more. Seventy-five to ninety per cent are common values.

The leaner mixes generally have more air voids than mixes near that which gives the lowest percentage of voids; richer mixes than the latter tend toward the value for neat cement paste, about 15 per cent of the total voids.

When a larger amount of mixing water than that giving minimum mortar volume is used, the proportion of air voids is decreased. A concrete having 30 to 40 per cent more mixing water than basic water content has the voids practically filled with water. This 30 or 40 per cent additional water content is accompanied by an increase in voids in the concrete of generally only 10 to 20 per cent of their value, though some of the sands gave a larger increase than this. For the wetter mixes the water content is a fairly good measure of the voids in concrete.

Minimum voids and basic water content give a rather dry mix, but it is evidently close to the point of maximum strength of concrete. Expressing the desired water content as a co-efficient times the basic water content would appear to be a definite and reasonable method. A specific co-efficient, however, when used with different values of b, or with fine aggregate of widely different quality, may not be expected to give the same mobility or workability. Both the slump test and the flow table give different results for a mixture high in coarse aggregate and for one low in coarse material, even though the degree of wetness of the material is apparently the same. The mobility of the concrete is dependent upon the amount of coarse materials as well as upon the wetness of the mix.

Possible Method of Specifying Aggregate Quality

The ease of making the mortar void test and the definiteness in the location of the point of minimum volume and in the increase of voids with the addition of water suggests the value of this method as a means of rating fine aggregates so far as the effect of the size of particles is concerned. There is such a variety of fine aggregate available in different parts of the country, very divergent in character, and the needs in concrete construction are so divergent that difficulty has been found in specifying a gradation or a size of particles that is generally acceptable. The test of a sand to determine the mortar voids, with characteristic mortar curves at several water contents, such as are shown in Fig. 6, will enable a study to be made of the concrete-making properties of the sand, and it may be rated or judged from these curves. In making up specifications for fine aggregate, generally only the voids at minimum mortar volume for a definite richness of mix need be considered. The requirement may take one of several forms:

1. A maximum limit of voids for a given mix may be specified, say for a ratio a/c of 2½. The value of this specified maximum may then be fixed for a given locality or a given purpose, according to the materials available.

2. A maximum limit of voids for a given mix may be specified for use with the specified proportion of cement to aggregate; a fine aggregate with mortar voids exceeding this, up to a given limit, may be used, provided the amount of cement per unit of volume of concrete is increased sufficiently to give a concrete coming within a cement voids ratio which would be specified.

3. The limit of voids may be set quite high and the requirement made that for the fine aggregate used the amount of cement and the proportions of the cement, fine and coarse aggregate, and water shall be such that the cement-voids ratio of the resulting concrete shall come within a specified limit.

If the general quality of the fine aggregate in other directions than size and gradation were not known, as in a sand which may be weak in structure, or which may have a poor surface for adhesion, or in a new and untried light aggregate, a strength test should be made in such way as to give a comparison with mortar or concrete made with a fine aggregate of known quality. For such a test the two fine aggregates should have the same gradation of particles.

The laboratory procedure in making the tests herein reported did not differ materially from ordinary practice.

The observed voids in the concrete test specimens checked rather closely with the predetermined values obtained by calculation from the mortar curves. The average variation from the expected value for 60 sets of test specimens examined was less than 1 per cent of voids, the observed value most generally being above the calculated value. In some of the specimens with the larger values of b it was found that the mortar did not fill the voids throughout the specimen.

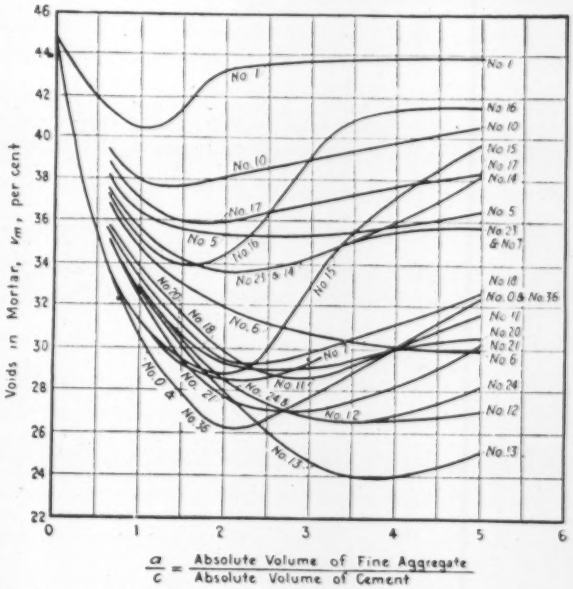


FIG. 8. CHARACTERISTIC MORTAR VOIDS CURVES FOR A VARIETY OF FINE AGGREGATES

As the sum of the solids in the concrete test specimens was found most frequently to be less than unity, it may be considered advisable to modify Eq. 2 by making the second member of Eq. 2 say, 0.995 or 0.99 instead of 1, or perhaps a better plan would be instead to give a coefficient of say, 1.01 or 1.02 to b in the first member of the equation. Such a modification would provide for increase in voids due to the separation or wedging of the particles of the coarse aggregate by the mortar, something which is especially likely to be present when a large proportion of coarse aggregate is used. It was found also in making calculations with data of another laboratory that the sum of the mortar volume and that of the coarse aggregate seemed to be 0.99 or even less, though part of the difference may be due to difference in testing methods.

With reference to the sieve analyses of the fine aggregates, it may be said that they do not bring out all the differences in the characteristics of the fine aggregates shown in Fig. 8; they of course show general differences in gradation. From physical considerations it seems evident that a sieve analysis, or a function derived therefrom, cannot be expected generally to measure or determine the voids in the concrete, because (1) a group of particles of about the same size near the upper or lower size, or at some intermediate size, may be sufficiently in excess of its proportionate amount of volume to interfere with the law of voids which may govern with regularly graded particles, (2) the sieve analysis does not take into account the bulking of the particles when wet, nor the difference in the amount of bulking for particles of different size, and (3) the sieve analysis for the reason given in (1) cannot take into account the changes in bulk due to a change in the amount of the cement used in the mix.

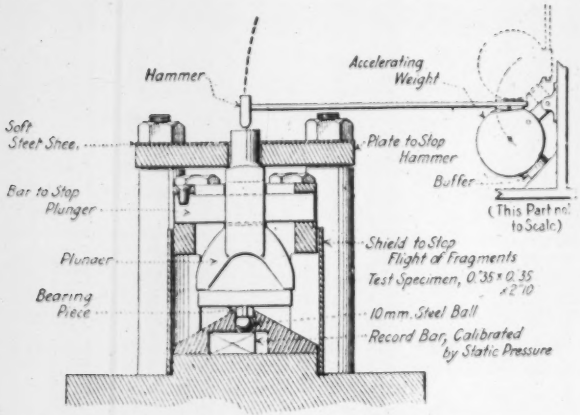
It follows then that while such devices as fineness modulus, surface modulus, and surface area may give a fairly satisfactory way of representing the voids function in material having certain regular gradations of size used with a certain proportion of cement and having certain degrees of bulking, they cannot represent at all generally the variety of differences in grading and bulking and the variety in the

cement proportions that are found in the general run of aggregates and concrete mixtures.

The mortar voids test takes account of the factors which give uncertainty to the sieve analysis function. If the requirements for structural strength and surface adhesibility be otherwise guarded, it will enable new or untried materials to be judged. It is of interest in showing what range of mortar richness will produce best results and what conditions will permit the use of what may have been thought to be a poor aggregate. Doubtless further study and experience will develop many limitations and suggest modifications and standardization of methods. It is evident that for the condition of mortar not filling the voids in the coarse aggregate there must be a limit to the applicability of the voids-strength relation. The shrinkage of wet mixtures and rich mixtures must be taken into account in the measurement of voids. Only physical conditions are here considered and any difference in conditions that affects the chemical action of setting and hardening is a separate factor. In practical use the fine material of the coarse aggregate will have to be counted in with the fine aggregate, and the coarse material of the fine aggregate as part of the coarse aggregate. When using coarse aggregate of the smaller sizes it may be found desirable to use a screen smaller than ¼ in. as the limit between fine and coarse aggregate. The variations inherent in fabricated materials must be expected to affect the accuracy of the findings, as will the errors of measurement involved in the testing processes.

A New Impact Test for Steel

AS A means of measuring the yield strength of hardened steel under a blow or suddenly applied load, C. E. Margerun developed a peculiar form of impact testing machine for naval service, in which he measures the force which a hammer-blow exerts in bending a short beam-like specimen. A diagram of the apparatus is given in the accompanying illustration, taken from a paper read by the author before the American Society for Testing Materials last month. The hammer by which the blow is delivered to the upper end of the load applying yoke is so arranged as to be capable of striking at



APPARATUS FOR TESTING "SHOCK STRENGTH"

any predetermined velocity up to 32 ft. per sec. The span of the yoke is 1¾ in. The pressure exerted during the bending of the test specimen is measured by the indentation of a hardened steel ball in a 1½ x ½ x 10-in. piece of forged chrome nickel steel quenched and drawn to about 270 Brinell. Such a test bar will record about 200 impressions. It is calibrated by making a number of impressions under static loads from 7,500 to 12,500 lb. The precise velocity of the hammer is in most cases not of material influence on the test.

Extension of Tall Steel Building Involves Unique Operations

Column Shifted To Give Symmetry to Face of New Structure—First Floor Lowered—Work Done With Building Occupied

A BOLD and unique operation was included in the extension of the 20-story American Surety Building, New York City, the floor space of which has been more than doubled by additions to the east and south.

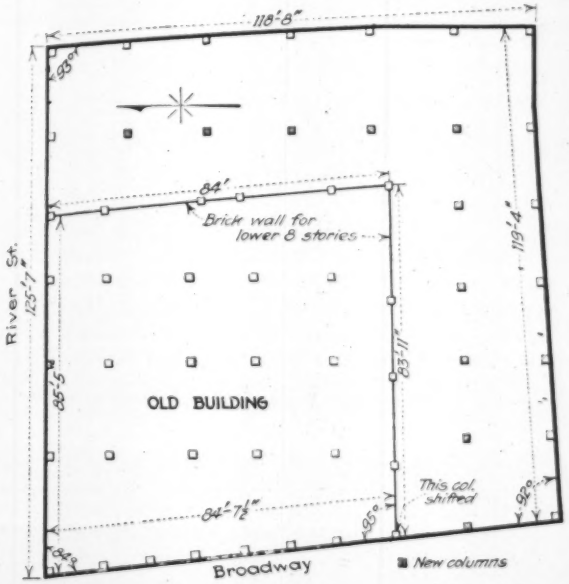
FIG. 1. LOOKING NORTH TOWARD SOUTH WALL OF BUILDING DURING CHANGES

Wall removed in upper floor preparatory to making addition. Trinity Church in foreground and Equitable Bldg. in rear.

In order to maintain the architectural symmetry of the extended building the steel column at the southwest corner of the old building was shifted throughout its full height of 20 stories northward a distance of 2 ft. 11 in. Though this was the crucial operation there were other interesting items in the work, such as the lowering of the entire first floor about 4 ft.; the difficulties encountered in construction because of the presence of a brick bearing wall in the lower eight stories of the east and south walls of the old building; and the preparation of the column foundations for the extension. All of these operations were influenced by the fact that the building was occupied the entire time. The operations from the

standpoint of relative interest are described in the following paragraphs.

Column Shifted—Because of the prominent location of the building—Broadway and Pine Sts.—it was decided that considerable expense was justified in maintaining the same bay width across the entire Broadway face of the extended structure so that the architectural detail of the old building could be maintained in the extension. This plan necessitated the shifting of the



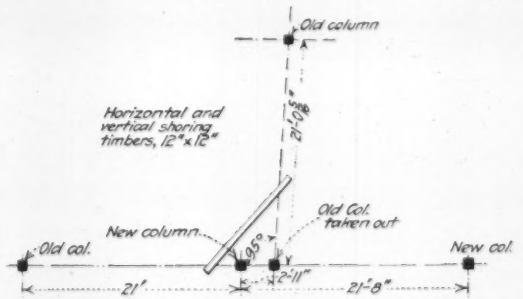


FIG. 2. GROUND FLOOR PLAN AND DETAILS OF COLUMN CHANGE

southwest column a distance of 2 ft. 11 in. To do this the steel on the south wall was exposed, the operation beginning at the top of the building. The masonry was picked away from the steel for a distance of about 10 ft. in from each wall at the corner, temporary partitions being put up as fast as the steel was exposed.

When the temporary walls had been installed the column was shored from sub-cellar to roof, the system of shoring being shown in Figs. 2 and 3. The timbers used in shoring were 12 x 12 in. placed on screw jacks. Shoring started at the bottom with the use of eight timbers and the number was gradually diminished until, at the top, two were used. These timbers were located in clusters of equal number directly to the north and east of the old columns. When shored and wedged the column connections were burned off, work being done from the top downward. The girders were burned off at the new position of the column, and enough of the girder was left upon which to frame the new connections. This done the column was removed, new steel in extensions being erected in the meantime. As fast as the old column was removed connections were prepared on the new steel for the column. When the removal of the old column was complete erection of the new column in the new location was started. After the steel had been erected above the fifteenth floor removal of the shoring began so that work upon the stone facing could begin.

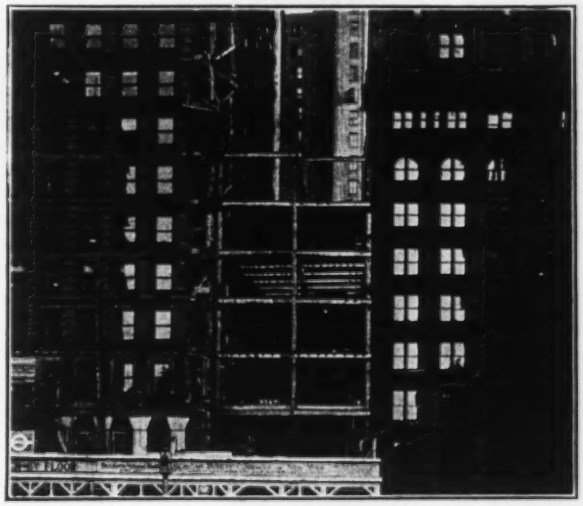


FIG. 3. OLD COLUMN OUT—SHORING DETAIL SHOWN

First Floor Lowered—In order to give a level entrance from the street to the corridor of the reconstructed building the entire ground floor was dropped

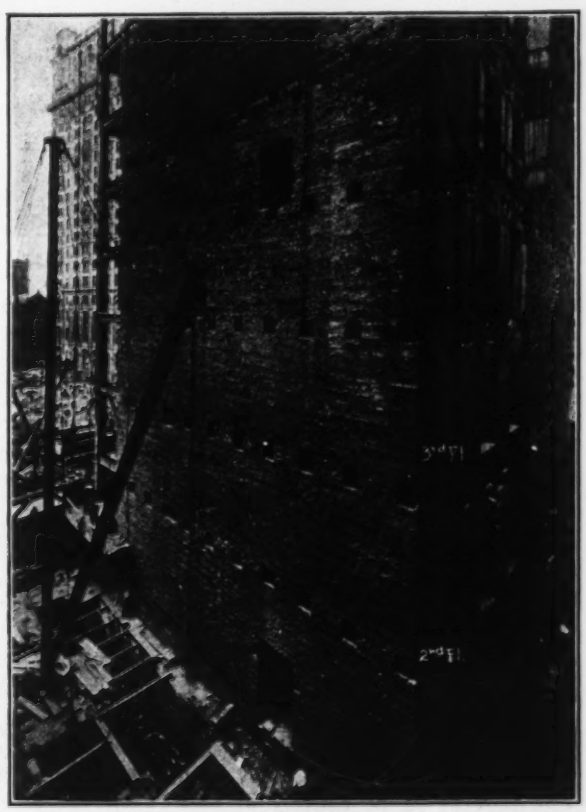


FIG. 4. MASONRY WALL RECESSED TO TAKE TEMPORARY BEARING OF NEW STEEL

approximately 4 ft. All the steam, plumbing and electric mains for the building were fastened to the underside of the first floor, and it was necessary, before starting to lower any of the floor, to drop all of this mechanical equipment and support it from the basement floor. In lowering the floor it was impossible to drop it as a unit as it was occupied and the corridor had to be kept open until the new elevators were put into operation. The north section was first lowered, then the south section, the section occupied by the corridor and elevator shafts being the last dropped. The north and south sections were lowered

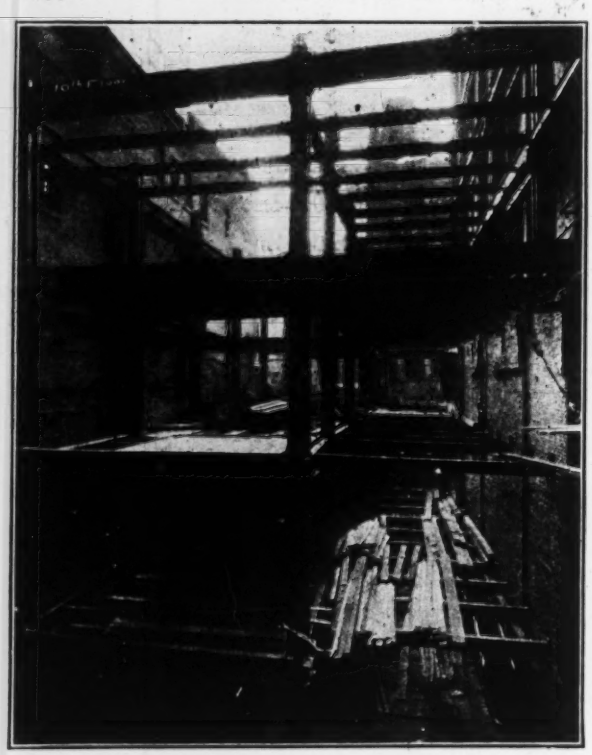


FIG. 5. NEW STEEL CARRIED ABOVE MASONRY WALL

panel by panel, floor beams were taken out and care was exercised that in no case more than one girder connection was cut on each column at a time. Concrete floor arches were then poured and the operation was duplicated in the south section, after the tenants had moved to the north section.

These two operations left the corridor of the building at its original elevation. During the time the two sections were being lowered the new steel for the section under the elevators and main corridor was being fabricated. Steel under the corridor was therefore put in and floor arches poured under the then existing floor construction of the corridor. All that remained to be done in the corridor then was to tear out the old construction as soon as the elevators in the new building could be put in operation and the old ones discontinued.

Removal of Bearing Wall—The old building was constructed about 25 years ago, being one of the first tall steel buildings in New York City. Though it was thought to be entirely of steel when the steel on the south wall was exposed it was found that below the eighth floor a brick bearing wall of an average thickness of 4 ft. had been constructed, the floor steel taking bearing in this wall, but the columns continuing through it to their footings. No other steel than the columns and occasional 15-in. channels was found in the south and east walls below the eighth floor.

Before the wall could be removed it was necessary to carry the new steelwork up beyond the eighth floor, making connections between the new portions of the building and the old at that height and then working downward, putting in steel and taking out the bearing wall. The bearing wall was notched at each floor so that floor steel could rest in the wall before it was possible to connect it to beams.

In the extension of the building the demolition of the eight-story Schermerhorn building to the south was necessary. Inasmuch as tenants in that building had leases that did not expire until long after expansion of the Surety Building was decided upon, the decision was made to prepare column foundations in advance of demolition. The new column foundations are clusters of six 15-in. steel cylinders, concrete filled. The cylinders were driven to refusal or rock, the penetration being from 67 to 79 ft., very few of them being driven the minimum distance. Hydraulic jacks were used for driving, until possession of the first floor was gained, when the additional headroom allowed the use of steam and air hammers. The same system of foundation work was carried out to the east of the old building.

Inasmuch as the cut-off elevation of the cylinders was below water level in many cases, the cylinders were generally allowed to project several feet above the cut-off elevation, being burned off at the proper level after being filled with concrete.

All of the steel uncovered in the old building was found to be in excellent condition. Only occasional rust spots were found, it being entirely unnecessary to replace any of the old steel because of deterioration. The only new steel members placed in the old building were a few heavier columns in the two upper stories, put in to take the load imposed by a two-story steel penthouse.

When excavation for the sub-basement began the contractor encountered considerable difficulty in removing old engine beds and boiler pits in the basement of the old building. During the past 25 years various changes had been made in boiler installation and each change resulted in new concrete. Two concrete machinery beds that had to be removed were 15 x 30 x 15 ft., and 10 x 15 x 10 ft. in size.

The general contract for the reconstruction work was held by Cauldwell, Wingate & Co., with D. E. Moran as consulting engineer. The foundation work was done by Spencer, White & Prentis, under the direction of the general contractor and Mr. Moran. The architect for the work was Herman Lee Meader. Richard Deming, vice president of the American Surety Company, superintended the work for the surety company.

Court Holds State Cement Plant Legal

At the request of the Governor of South Dakota the judges of the Supreme Court of that state have passed upon the legality of a state-owned and operated cement plant. The opinion of the court is that this would be legal. (180 N. W., 957.)

Impressions Here and There

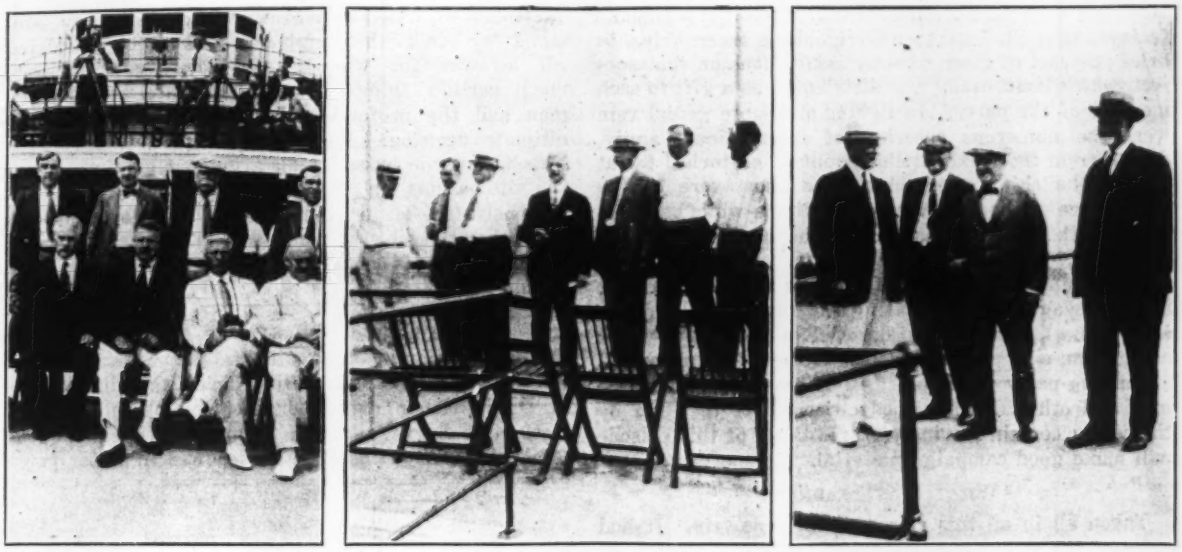
Down the St. Lawrence Waterway

INSPECTING engineering jobs is a favorite pastime for engineers. This is quite right and proper even though at times it does get pretty close to the old joke about the motorman taking his day off riding on the street cars. Seeing how the other fellow does it is the beginning of knowledge, provided the critical faculty is not overexercised and disparaging comparisons not overemphasized. Such inspections, though, are generally in company with other engineers—the byproduct of conventions or the express object of an engineering meeting, so that in addition to practical education they serve to develop that class consciousness that so many of our active thinkers would have us regard as the profession's salvation. It is a good thing, on the other hand, for every engineer every so often to separate himself from his own crowd and travel as a spectator over big engineering works in company with men who are not engineers—men to whom the commonplaces of construction are wonders and the elements of design and function mysteries.

Such an opportunity was afforded a few engineers two weeks ago when they were invited to attend the excursion of the Great Lakes-St. Lawrence Tidewater Association on the steamer "Cape Eternity" from Niagara down the St. Lawrence to Quebec. Over 150 men made up the party as guests of the Canadian government, to view on the ground the potential St. Lawrence waterway and power development on which the International Joint Commission is about to report and which is to be much in the public eye in the near future. It was a serious expedition, albeit a good-natured and happy one, with representatives of the Northwest that is seeking a cheap waterway outlet for its grain and other freight, with New Englanders hungry for cheap power but skeptical of the economics of the grand scheme, with Canadian cabinet ministers and their great ex-premier Sir Robert Borden, with six governors and four of the ex variety, with senators and congressmen, merchants, manufacturers and farmers—and perhaps half a dozen engineers. Few had ever seen the St. Lawrence except as tourists; all were interested in its power and navigation possibilities.

In a way the trip was propaganda. The Westerners planned it and the Canadian government acted as host. The rest of the party came "for to admire and for to see." But it was shrewdly planned propaganda, honestly put forward by men who believe in this great project and who want to convince those who may be most benefited but who are "from Missouri" as to those benefits, or, as they more politely put it, "are still of an open mind." Inspection of the waterway itself and the sites of the proposed structures was skillfully varied with views of the completed or partly completed harbor and power works of the Canadian governments and with addresses and lectures on the features and possibilities of the complete scheme. What has been done was used to illustrate what can be done, and good feeling promoted by most bountiful hospitality by the Canadian cities along the route.

The trip started at Niagara with an inspection of the Queenston-Chippawa power development now being completed by the Province of Ontario. Engineers realize that this is the biggest piece of construction on the continent and one of the boldest financial ventures ever undertaken by a government, but to most of those of the party it was a revelation. They were all properly impressed with the magnitude of the project, on which some 8,000 men were working the day of the visit, though somewhat skeptical of its economics and doubtful of the market for the 500,000 hp. it will produce. From there they were taken over the new Welland Canal which, delayed by the war, is still far from completion but which is sufficiently far along, especially in the great locks, to show that the upper link in the



NOTABLES ON BOARD "CAPE ETERNITY" EN ROUTE DOWN THE ST. LAWRENCE

At left (lower row)—Sir Robert Borden, Sir Henry Drayton, Canadian Minister of Finance; W. A. Bowden, chief engineer, Canadian Department of Railways and Canals; Hon. Frank Keefer, M. P. (Upper row) Members of Canadian and Ontario Parliaments.

Middle—Ex-Gov. Frank Lowden, of Illinois; Gov. McMasters, S. D.; Gov. Allen, Kans.; Gov. San Souci, R. I.; Gov. Hartness, Vt.; Ex.-Gov. Milliken, Maine; Gov. Preuss, Minn.

Right—Senators Townsend, Mich., Lenroot, Wis., McKinley, Ill., Ransdell, La.

30-ft. opening of the Great Lakes to the sea is on the way to being an accomplished fact. At the Lake Ontario end of the canal the "Cape Eternity" was boarded and the party stayed on her to Quebec, with stops at Toronto, where a great industrial development is masquerading as a harbor project, at Montreal long enough to see what a real river harbor can be made and at Quebec to view the more limited harbor work required at a city where industrial development is meagre.

During the boat trip frequent meetings were held aboard ship. Col. W. P. Wooten, the United States army engineer and W. A. Bowden, the chief engineer of the Canadian Department of Railways and Canals, explained their joint report to the International Joint Commission on the engineering necessities of a St. Lawrence waterway. William S. Murray outlined the features of his recently made Super-Power Survey of the Northeastern part of the United States. R. S. McElwee and A. H. Ritter lectured on the economic features of a St. Lawrence navigable to ocean ships, in brief abstract of their recently issued book on that subject, which incidentally was distributed as a gift to each member of the party. In lighter and more genial vein were the numerous speeches of international amity, drawn from the inexhaustible fount of oratorical talent aboard the ship. Appreciative as they were of the importance of the fact, the party after a while began to await with laughing expectancy the certain reference to the "4,000 miles of boundary for a hundred years without gun or fortress." Meanwhile all the lower part of the voyage was made along the rapids and through the locks which must be improved to make deep-water navigation, with an interlude in the way of a lightly clad swimming party participated in by governors, congressmen and other distinguished citizens. If they get by the censor certain moving pictures taken of this episode will make good campaign material.

What Was Learned

Taken all in all this was a remarkable trip. It had some of the elements of a junket. A few aboard were out only for a good time, but the great majority were serious minded men on whom will rest either the responsibility for forwarding legislation or of informing the business men of their community of the faults or virtues of the St. Lawrence scheme. The echoes of the trip will be heard in the halls of Congress and the Canadian Parliament and in the public discussions from North Dakota to Maine. It was the opening gun in the campaign which is to be waged as soon as the International Joint Commission makes its report in October and which may result in the expenditure of half-a-billion dollars and the revision of the trade routes of the continent and the power plan of the whole Northeast.

As to the scheme itself, the excursion showed those who made it certain things. They learned that Canada, with the exception of some of Quebec, is for the opening of the St. Lawrence; they learned that Ontario, far advanced in government ownership, is convinced of the necessity for enormous water-power development by the state; they saw cheap power offered to the citizens who so far are not convinced of any added charges camouflaged as taxes; they saw a great wide river for the most part as easy of navigation as the open sea but they saw also canals and locks through which the comparatively small "Cape Eternity" progressed slowly and with difficulty; they saw a dam site whose difficulties loom tremendously in the engineering eye only as a place where engineers say a dam can be built, and they accepted that assurance with calm confidence.

This last observation leads us back to the reflections in the opening paragraph. Engineers need to get out with the men who in the end dictate or control the work the engineers do. They need more to learn how engineering work is regarded. On the St. Lawrence trip the statements of the engineers as to engineering problems and solutions were accepted without question; there was an almost touching belief that nothing is impossible. No engineer present could escape the feeling of responsibility which the profession must assume. But the regard for engineering opinion stopped at what the layman considers the limit of engineering knowledge, that is, the design and construction of engineering works. When it came to economic questions, such things as the navigability of the proposed waterway, the diversion of freight, the effect of rates, in effect the ultimate questions on which the St. Lawrence waterway must stand or fall, the engineer was not considered. All he was for was to say where and for how much certain things should be built; the business man and the professional economist must make the ultimate decision. Possibly this is as it should be. This is not the place for an argument on that, but all the discussions on the "status of the engineer" so emphasize the larger and wider field of the engineer's work that this observation, made under most favorable circumstances, is set down for what it is worth.

July 22, 1921. F. C. W.

California Water Powers Tabulated

A compilation of data on all water powers in California has recently been made under the direction of H. D. McGlashan, district engineer of the United States Geological Survey at San Francisco, which shows a total of 1,107,139 installed horsepower in water power plants of that state. Plants with a capacity less than one hundred horsepower are not included. The information is arranged in two classifications so that it can be studied either by counties or by drainage basins. A summary of the data is presented in the table above.

DEVELOPED WATER POWER IN CALIFORNIA

	Public Utility Plants	Municipal Plants	Mining Plants	Total or Average
Installed horsepower	989,314	101,140	16,685	1,107,139
Number of plants	87	15	28	130
Average horsepower per plant	11,371	6,743	596	8,516
Number of water wheel units	230	28	70	328
Number of turbines	62	14	10	86
Number of impulse wheels	168	14	60	242
Average horsepower per wheel unit	4,301	3,612	238	3,373
Storage used in acre-ft	1,554,321	124,540	9,400	1,688,261
Average head developed, in ft	647	542	418	587
Maximum head developed, in ft	2,131	1,266	1,250	.....
Minimum head developed, in ft	12	10	24	.....

Electrification in Australia

Progress on the electrification of the suburban system of the Victoria Government Railways at Melbourne, the capital city of Victoria, Australia, was interfered with to such an extent by the war and the industrial difficulties which followed it, that the work will not be completed until some time in 1923. The lines already in operation and others to be put in service in 1921 will comprise about half the suburban system. According to the annual report of the Railways Commissioners the electric services have given satisfaction and the complete scheme will provide a greatly improved system of rapid transit which will enable additional services to be afforded at less cost than for steam operation.

Tests on Run-Off from Muck Soil in the Everglades

Storage of Rainfall on Important Property—Ditch Size Must Allow for Subsidence Due to Drainage—Run-Off Formula

IN LAND drainage work where muck or peat soil is encountered, certain characteristics of such soil in regard to water storage and soil subsidence constitute a special factor as they produce conditions differing somewhat from those experienced ordinarily in the drainage of loam, clay or sandy soils. Experiments to determine the run-off from muck soil have been made by F. C. Elliot, chief engineer of the Everglades Drainage District, and the following is an abstract of a paper by him in the *Year Book* of the Florida Engineering Society.

Muck and peat soils have a high normal water content, due partly to their humous composition, which gives them a greater affinity for water than the common mineral soils, and partly to the large relative pore space accompanied by a high degree of capillarity. Part of this pore space is in the loose character of the soil itself and part in the cellular structure of the muck. Part of the water held by saturated muck is released readily by drainage and about an equal amount is quickly reabsorbed by drained soil when moisture is supplied by rainfall. Percolation and capillarity are important considerations in connection with water storage in the soils. Through drainage and cultivation these soils are subject to a marked degree of shrinkage.

Water storage in the soil and shrinkage or subsidence of the soil bear directly upon the problems of determining: (1) A satisfactory run-off factor, and (2) the ditch design best suited to afford the required run-off, to provide flood protection and to give satisfactory ground water levels for agricultural purposes. Experiments have been made for the determination of a reasonable and economical run-off for providing that degree of drainage considered advisable for the Everglades. In arriving at final results the following principal factors were investigated: (1) Storage or absorption value of muck soil under actual field conditions; (2) evaporation from such soil, including transpiration of water from vegetation; (3) the advantageous water level for the growing of crops, combined with a high degree of flood protection; (4) the effect of the water level and land tillage upon subsidence and the degree to which subsidence should be compensated for in ditch construction.

Test Apparatus

For these experiments a sheet-iron box is used, 2 ft. square and 4 ft. deep, the seams being riveted and soldered to secure perfect water tightness. To the outside of the box is attached a water gage glass connected with the interior by a valve at the bottom and a pipe nipple at the top.

The glass has a gage divided into inches reading zero at the top and graduated downward for depths below the surface of the soil. The box rests near the ground and is inclosed and protected by a lattice against the rays of the sun. A section of muck soil in its natural condition was placed in the box, filling it level full. Augustine grass and Bermuda grass were planted and water added to bring the water table to a convenient starting point. In conjunction with the soil box a rain gage is observed. Soil water levels are recorded from test holes in the natural muck soil at the station. Water evaporation pans are also kept for comparison of evaporation between water surface and losses from evaporation and transpiration from the soil box.

In operation, the water gage is read and tabulated to show the level of ground water below the surface of the soil, records being taken each morning and after such rains as require additional measurements. Observation is made upon the growing vegetation. The rain water gage is read and recorded, and the level of water in the test hole is recorded. Water can enter the box only through rainfall, which is measured by the rain gage. Water can escape only by evaporation, which is measured, and by being drawn through the bottom valve, which represents drainage. Evaporation includes loss direct from the soil and by transpiration through the vegetation.

Evaporation is disclosed by the lowering of the water level and rainfall produces a rise in this level. The rain gage measures the amount of rain, and the water glass on the soil box shows the corresponding rise in the water level. By numerous repetitions there is disclosed a ratio between rainfall and rise of water and a ratio between evaporation and the lowering of the water level. For example, in the morning the soil box gage may show the water level at 32 in. During the day a rain of 0.6 in. is recorded. On the next morning the gage shows 29 in. Ignoring evaporation, it appears that three inches of soil were required to store or absorb 0.6 in. of rain.

To determine the evaporation which took place from the soil daily and for the month, the rainfall is gaged for the month and at the end of the period water is either added to or drawn from the box to restore the water level to the same level as at the beginning of the month. In addition to this water, allowance is made for rainfall. The water which entered the box having been measured, and the amount drawn off as drainage (if any) also being measured, the quantity not otherwise accounted for represents evaporation. Through these experiments the storage value of the soil is ascertained.

Soil Storage and Shrinkage

Soil Storage—An important disclosure by the experiments is that muck soil has an important and valuable storage capacity when the water table is at a favorable level. The records of the soil boxes showed in the beginning that each 3 in. of soil above water level was capable of storing one inch of rain. After the soil became more compact by tillage and drainage the storage factor was reduced to 1 to 4 and finally 1 to 5, which latter has been maintained for the past three years. It is probable that a further reduction of storage value will take place in time, and conservative drainage design would take this into consideration.

Conclusions as to soil storage may be stated as follows: (1) The storage capacity of muck soil is a valuable drainage factor; (2) the value of this storage varies directly as the depth of soil above the water table; (3) storage capacity of the soil under favorable water table conditions will permit taking advantage of evaporation to assist drainage; (4) in designing a drainage system for muck land, account may be taken of the storage value of the soil, provided ditches of relatively deep section are used and at sufficiently close intervals to secure a good depth of water table and for restoring and preserving the storage value of the soil; this operation will approach subsurface drainage; (5) soil storage tends to equalize run-off and this effect will extend to the main canal system as well as to the lateral system; (6) deep soil above the water table is a tremendous protection against flood.

Levels taken over selected areas during a period of six years show that during the past six years subsidence of 2 to 3½ ft. has taken place generally over the upper Everglades on land drained or partly drained, varying according to depth of soil, character of muck, extent of cultivation and depth of normal water level. The soil was 10 to 12 ft. deep. A total subsidence of 4 to 6 ft. in 10 to 12 years more, under continued drainage and cultivation, does not seem improbable. Subsidence diminishes ditch capacity principally by the material reduction in ditch section through diminished depth of ditch and by reducing the slope or grade of the ditch.

Our experiments show that for soils of given depths the amount and rate of subsidence are affected largely by the depth of water table. The deeper this is, the greater and more rapid the subsidence, and the shallower the water level the slower the settlement. Therefore, too deep drainage should be guarded against, not only from the standpoint of subsidence, but also because muck, when it becomes too dry, has the peculiar property of resisting the reabsorption of moisture, the continual replenishing of which is necessary to plant growth.

Drainage Layout—Based on observation of muck soil under the conditions met with in the Everglades, the following conforms to a satisfactory drainage layout for muck land such as described. Discharge capacities are represented by

$$D = \frac{12}{1 + \sqrt{A}} + 16,$$

where D equals discharge in cubic feet per second per square mile and A equals area in square miles. Maximum water level in ditch, 1 ft. below ground surface; depth of lateral ditches, not less than 5½ ft.; reduction of water level before beginning of rainy season, to not less than 50 in. below ground surface. Lateral ditch intervals, not over half a mile. Farm ditch intervals, not over 660 ft.; depth not less than 4½ ft. Farm drains according to needs, 110 ft. interval suggested.

Ditches and canals must be made sufficiently deep to compensate for loss by subsidence. In virgin muck soil 8 ft. or more in depth the ditches should be cut 8 ft. deep in order to have 5½ ft. depth after three or four years of drainage and cultivation. This minimum depth must be preserved by maintenance. Where partial subsidence has already taken place, allowance may be made accordingly. Within reasonable limits ditches should be deep and narrow rather than broad and shallow. The sides should be steep; side slopes of ¼ to 1 stand very well in ordinary muck. The steeper the sides, the less trouble from weed growth, which is the most serious source of ditch deterioration in muck soil.

An examination of the rainfall records of stations nearest the Everglades since 1895 shows that a general drainage plan such as above described would have given the following results: There would have been two general floods in twenty-five years during which water would have stood on the ground two days, and six local floods of small area, four of which would have required less than two days for their reduction and two would have required four days for reducing the water to sub-surface conditions. Only one locality would have had two local floods in the above time, and some localities would have been subjected only to the two general floods resulting from extreme rainfall.

Corporation Income Tax Returns Include Engineering Services

ENGINEERING is included in "professional and other services" in corporation returns reported in *Statistics of Income*, compiled from the returns for 1918 under the direction of the Commissioner of Internal Revenue. Corporation returns are divided into the three general classifications of public service, finance, and all others. The main division of public service is divided into domestic service, amusements, professional and other services. A tabulation representing "professional and other services" is reproduced herewith.

Inquiry of the Commissioner of Internal Revenue at Washington in regard to both engineers and physicians apparently being included under corporations develops the fact that the general classification was arranged to be broad enough to cover both returns of individuals and corporations so that the classification "Engineering, mechanical design, invention, scientific research, etc.," in its fuller aspect is given as follows: "Engineering, architects, agricultural, civil, chemical, consulting, electrical, marine, mechanical, mining engineers. Assayers' test or research laboratories, invention, mechanical design, metallurgists, mechanical experimentation or research. Scientific research. Surveyors."

Apparently no statistics have been developed indicating separately returns by individual engineers and by corporations.

INCOME TAX RETURNS OF CORPORATIONS RENDERING PROFESSIONAL SERVICE—1918

Industries	Total Number of Corporations	Corporations Reporting Net Income					Corporations Reporting No Net Income	
		Number	Net Income	Income Tax	War Profits and Excess Profits Tax	Total Tax	Number	Deficit
Professional and other services:								
Business services, advertising, appraisers, auditors, actuaries, etc.	1,178	773	$3,813,789	$327,209	$366,355	$693,564	405	$1,474,922
Educational service, including art, colleges, schools, libraries, etc., teachers, etc.	752	473	2,129,828	173,973	103,716	277,689	279	997,310
Curative services, physicians, surgeons, etc.	927	613	2,506,373	156,562	410,451	567,013	314	515,486
Legal services, lawyers, patent attorneys, etc.	910	683	2,700,117	228,174	69,311	297,485	227	257,673
Engineering, mechanical design, invention, scientific research, etc.	413	254	4,342,489	273,292	1,711,420	1,984,712	159	922,968
All other service (not precisely defined)	1,867	1,338	5,718,511	503,119	741,547	1,244,666	529	1,200,024
Total professional and other services	6,047	4,134	$21,211,107	$1,662,329	$3,402,800	$5,065,129	1,913	$5,368,383

Overhauling a Neglected Water-Works Distribution System

PROPER maintenance of a water-works distribution system is a continuous process that must be conscientiously kept up. No better illustration of the deplorable condition into which a system can get and the strenuous work necessary to restore its efficiency could be found than that of the Oklahoma City plant described recently by A. S. Holway, superintendent, before the Southwest Water Works Association:

The principal feeder to the city had 16 ungated hydrants on it and a blow-off of one of them had caused an 18-hour shut down to the whole business district. No large connections were made between the domestic supply and a downtown fire system supposed to be high pressure but for many years carrying the same pressure as the domestic lines. Valves broken closed, many packed with oakum, were common. In going over three-fourths of the 165-mile system 84 valves have been found paved over and 65 valves could not be operated because the operating nut was against the valve box. In one section containing 254 valves, 47 were not shown on available maps, 11 were shown which did not exist and 60 needed repairs. In this same section 3,000 ft. of mains were located that were not shown on the maps and 2,350 ft. shown did not exist. The size of nearly 10,000 ft. of pipe was incorrectly given.

An old negro, Claude, was finally found to be the best source of information. He with an engineer was detailed to travel the streets east and west, stopping at every street intersection in the city. He told the engineer as well as he could recall from water-boy days, what mains and valves were at each intersection. Subsequent investigations proved that Claude's memory was fully as reliable as the maps.

One of the means employed to get the records back to normal was a systematic use of information from new tap orders which requested location and size of main tapped. Most of the information, however, was obtained from the work of the valve repair crew which started at the outskirts of the city locating, operating and repairing all valves as they proceeded toward the center of the city. Mains were located with a wireless pipe locator. Many of the valves under pavements have been located with the dipping needle. To prevent breaking of stems from opening left-hand turn valves the wrong way a specially designed valve box is used for the right-hand turn valves with "open right" on the lid.

Results are beginning to show, said Mr. Holway. Recently a large circuit was closed in 28 min. which 15 months previously required four men two hours to close and then a perfect shutdown was not obtained.

Flow of Water Through Galvanized Spiral Riveted Steel Pipe

By F. W. Greve
Assistant Professor of Hydraulics Purdue University

THE experiments performed in the hydraulic laboratory of Purdue University on galvanized spiral riveted steel pipes were prompted by the meager data available. The diameters of the pipes tested were 4, 6, 8 and 10 in. respectively. The objects of the investigation were to determine: (1) the variation of the friction loss with velocity for flow, both with and against laps; (2) the variation in accuracy of four types of piezometer rings; and (3) the friction loss compared with that in cast-iron pipes for like conditions of diameter and velocity.

The pipes were all of No. 16 gage. The average spacing of the rivets was $\frac{7}{8}$ in. for both the 4 and 6-in. pipes, 1 in. for the 8- and $1\frac{1}{8}$ in. for the 10-in. pipe. The rivet heads on the inside of the pipes projected $\frac{1}{16}$ in. from the pipe wall and were flattened to reduce the resistance to flow. True cross sectional areas were determined by weighing the amount of water necessary to fill a given length of pipe and dividing this weight by the product of the length and the weight of a cubic foot of water which was 62.32 pounds.

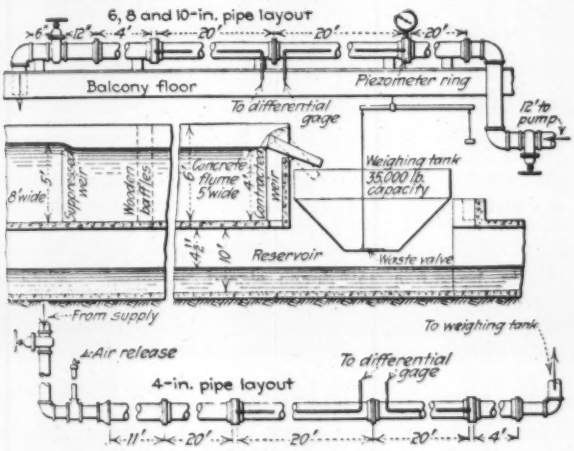


FIG. 1. LAYOUT OF PIPE LINES FOR TESTS

A spiral pipe line was composed of four sections, laid horizontally. Each of the first three sections was approximately 20 ft. long while the last was of 4-ft. length. Piezometer rings were inserted between the first and second and between the third and fourth sections from which rings the pressure was communicated through $\frac{1}{4}$-in. pipes to differential gages. The purpose of the first and last sections was to insure continuity of flow by having the water subjected to no change in velocity, diameter or rubbing surface when entering and leaving the tested lengths. The layout of the pipe lines is shown in Fig. 1.

The piezometer rings were made of cast-iron discs, 2 in. in thickness. In type A, a hole was bored through the disc equal in diameter to that of the spiral pipe. Type B differed from A in that it had a chamber machined out on the inner surface, $\frac{1}{2}$ in. wide by $\frac{3}{8}$ in. deep. The $\frac{1}{4}$-in. pipes were connected to both rings at four points—one at the top, another at the bottom and the last two diametrically opposite each other midway between the top and the bottom. Types C and D were the same as A and B, respectively, except that three of the holes were plugged, leaving only one opening at the same elevation as the center line of the pipe. Ring C was used in all tests. The other three were employed only in the experiments on the 6-in. pipe, to determine what change, if any, was produced on the differential gages by the several types of piezometer rings.

The water was supplied through cast-iron mains from a 6-in. direct-driven, centrifugal pump. The flow from spiral pipes passed either directly or indirectly through a cast-iron pipe into a large concrete channel, 5 x 40 ft. in plan and 6 ft. deep. The discharge from this channel was over a suppressed rectangular weir and moveable apron into a calibrated weighing tank of 20 tons capacity. A piezometer situated up stream from the weir was used to determine the condition of steady flow. Time was indicated on a calibrated stopwatch.

Fig. 2 shows the relation of friction head per 100 ft. of pipe to velocity for flow both with and against laps on logarithmic paper. The graphs are straight lines, indicating that the head lost varies directly as some power of the velocity. The graphs are nearly parallel lines, which demonstrates that the slope varies but little with the size of pipe. This figure also shows that the loss decreases with increase of diameter for any given velocity; that the loss is greater for flow against than with laps; and that the difference of loss with and against laps decreases with increase of diameter. That the effect of direction of flow becomes correspondingly less as the size increases is to be expected since the thickness of the lap is a constant for the pipes tested and, therefore, the ratio of this thickness, or projection, to the diameter decreases with diameter. Thus, the large sizes approach the conditions of smooth pipes.

TABLE I. VARIATION OF m AND n IN THE EQUATION $h_L = mv^n$

Nominal Diameter, In.	True Diameter, In.	m With Laps	m Against Laps	n With Laps	n Against Laps
4	4.13	0.115	0.138	1.86	1.91
6	6.01	0.0843	0.0875	1.91	1.95
8	8.12	0.0669	0.0739	1.92	1.89
10	10.21	0.0554	0.0597	1.82	1.80

The graphs are all of the form, $h_L = mv^n$. The value of the coefficient and exponent are given in Table I. The relation of m to d can be expressed by the logarithmic equation, $m = kd^x$. Table II shows the variation of k and x with m.

TABLE II. VARIATION OF k AND x IN THE EQUATION, $m = kd^x$.

	With Laps	Against Laps
k	0.0488	0.0515
x	−0.799	−0.926

The ratio of n to d can be best expressed by the cubical equation, $n = ad^3 + bd^2 + cd + e$. The limits of usefulness of the equation were found by determining the point of inflection when the second derivative of the equation was made equal to zero. The equation for flow with laps holds good for all values of d equal to 4 in. and greater and is true for all positive values of d when the flow is directed against the laps. The relations thus established furnish a means of computing m and n for any diameter of pipe. Heretofore, no data have been available to predict the friction loss in a pipe on which experiments have not been conducted.

The effect of different types of piezometer rings on the measurement of lost head in connection with the tests on the 6-in. pipe is shown in Fig. 3. It will be noticed that practically identical results are obtained no matter which type of ring is used.

A comparison was made of the friction losses per 100 ft. of pipe for both smooth cast-iron and galvanized spiral-riveted steel pipes. The losses for the iron pipe were computed from Williams and Hazen's "Hydraulic Tables." When the flow is directed with the laps, the 4-in. spiral riveted pipe shows a lesser loss than the iron pipe of like diameter. The reverse is true for all the larger pipes. However, the difference is small and in no case is it sufficient to warrant the spiral pipe to be classified as unfavorable because of friction losses.

The conclusions to be derived from the investigation are as follows: (1) The friction loss in galvanized, spiral riveted, steel pipes when the flow is with the laps is little different from that in smooth cast iron pipes. (2) Spiral pipes should be laid so that the flow is with the laps. (3) The friction loss may be expressed as, $h_L = mv^n$, where h_L is the loss due to friction expressed in feet of water; v is the true mean velocity in feet per second; m is the value of h_L when v is 1 ft. per second; and n is the slope that the graph expressing the relation of h_L to v makes with the horizontal. (4) The relations of m and n to d are readily established, allowing the friction loss to be calculated for any size of spiral pipe when experimental data are not available.

A complete report of the investigation will be published in a bulletin of the Engineering Experiment Station of Purdue University.

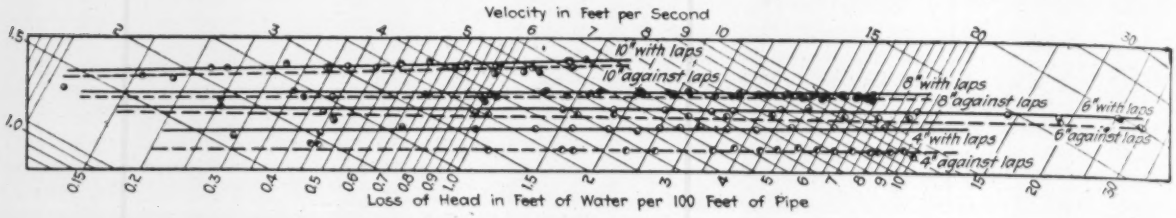

Velocity in Feet per Second
10" with laps
10" against laps
8" with laps
8" against laps
6" with laps
6" against laps
4" with laps
4" against laps
Loss of Head in Feet of Water per 100 Feet of Pipe

FIG. 2. RELATION OF FRICTION HEAD TO VELOCITY OF FLOW, BOTH WITH AND AGAINST LAPS

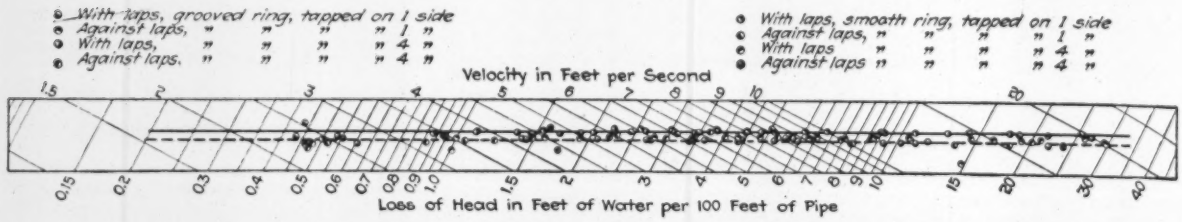

With laps, grooved ring, tapped on 1 side
Against laps, " " " " 1 "
With laps, " " " " 4 "
Against laps, " " " " 4 "
With laps, smooth ring, tapped on 1 side
Against laps, " " " " 1 "
With laps " " " " 4 "
Against laps " " " " 4 "
Velocity in Feet per Second
Loss of Head in Feet of Water per 100 Feet of Pipe

FIG. 3. EFFECT OF DIFFERENT TYPES OF PIEZOMETER HEADS ON LOST HEAD WITH 6-IN. PIPE

Underground Railway for Sydney

Construction of the underground rapid-transit line through the business district of Sydney, New South Wales, is to be resumed, work having been stopped in 1918 on account of war conditions. It is expected that bids will be called for in October and opened early in 1922. The estimated cost is about $12,000,000 at present rate of exchange. Plans have not been completed for the cantilever bridge of 1,600 ft. span which is to cross the harbor and connect two sections of the city. The cost of the bridge is estimated at $20,000,000. J. J. C. Bradfield is chief engineer of the Metropolitan Railway, which is a government enterprise. The rapid transit improvements were described in *Engineering News-Record*, July 8, 1920, p. 56.

Simplified Method of Plotting Transit and Stadia Traverses

By Herbert N. Bradstreet
U. S. Mineral Surveyor, Mesa, Ariz.

IN PLOTTING transit and stadia notes of traverses for mapping an area, after a hard day's field work, most engineers have had to spend weary nights in computing latitudes and departures so that the traverse to be plotted, because those in charge believed a traverse could not be plotted by turning angles with a protractor. The writer recently had occasion to make a contour map of a brushy river bottom comprising several channels and covering an area ½ to ¾ of a mile wide and three miles long. In getting the salient points, he ran a half-dozen closed traverses. When it came time to make the map on a scale of two hundred feet to the inch, he determined not to compute any co-ordinates, but to lay out the map with a protractor.

Through his initial point, he drew a cardinal line and from this line, laid off the first azimuth and distance. Through the second point by means of large triangles, he passed a guide line parallel to the first cardinal line, and again laid off the azimuth and length of the second course. Thus, through each transit station, a line parallel to the cardinal guide line was drawn and the proper deflection made from it. By this method, small errors in deflection angles did not become cumulative, but resulted only in slight displacement of plotted points. By using care, he was able to carry this system of parallel lines downstream for a distance of two miles and back again on the other side of the river to the original cardinal guide line, and still have his guide lines parallel to each other and the final line coincident with the original guide line. Not only did the traverse close well within the requirements of the map, but in one case where a mistake was made of 100 ft. in reading the stadia shot, the plotted traverse showed an error of 100 ft., and by the direction the final plotted point lay from the objective point, indicated the error must be in one of two or three sides of the polygon.

The author believes considerable time and fatigue was saved and the place of error most quickly determined.

LETTERS TO THE EDITOR

If you have ideas that would interest engineers and contractors we shall be glad to give them space here. We urge, however, that you be brief so that a wide range of subjects may be covered in the available space.—The Editor.

Solid vs. Pneumatic Tires for Trucks

Sir—We have heard from several sources propaganda directed at state highway engineers and county commissioners in the endeavor to induce them to restrict trucks engaged in the construction of highways to the use of pneumatic tires. The contention is that the pneumatic tire will not damage the incompleted road surface or subgrade to the same extent as a solid or cushion tire.

Let us, however, investigate the facts: Assuming a 7½-ton truck to be used, we find the weight on the rear wheels, taking into consideration the distribution of load, weight of the body and the like, to be a total of approximately 17,000 lb., or 8,500 lb. on each wheel. The biggest pneumatic tire yet developed, and which has not as yet proved a commercial success, is the 48 x 12-in. size, the manufacturers of which allow at present a load capacity of just 8,500 lb., *provided this tire is inflated to an air pressure of 140 lb.* This means that the weight per square inch of road contact will be 140 lb. and that the area of contact will be 61 sq.in.

This same truck would doubtless be equipped with 14-in. cushion or solid tires which would have a capacity of 12,000 lb., or 3,500 lb. more per wheel than the pneumatic. Tests have shown that the weight per inch of contact of solid-tired wheels is 105 lb. as against 140 lb. in the case of the pneumatic. We would, therefore, find that the area of contact of the non-resilient, solid tire is practically 81 sq.in. as compared with the 61 sq.in. of the pneumatic.

Inasmuch as road damage, rutting and the like is entirely a factor of weight per square inch of road contact, it is easy to see that the properly selected solid tire will in reality cause less road damage to a soft surface than will a properly inflated pneumatic tire. If we consider the semi-solid or cushion type of tire, in which the area of contact is considerably increased above that of the solid, we will find the ideal equipment for soft or uncompleted road surfaces.

This is an important matter and yet is one which has been too hastily investigated by many road commissioners. It is simply a question of elementary mathematics.

H. W. SLAUSON,
Engineering Service Manager, Kelly-Springfield Tire Co.
New York, July 13.

Credit for Designing School in New York

Sir—I was interested in the article entitled "How One Consulting Engineer Got a Job," by Elwyn E. Seelye, in *Engineering News-Record*, June 2, 1921, p. 940. Mr. Seelye in that article gives the impression, first, that the work was handled by him alone, and, second, that the type of construction was worked out by him. Though interesting, the description diverges from the actual facts, which I will state.

The work described in the above noted article was handled under the firm name of Seelye & Fraser, since dissolved, in which the writer represented the Fraser part. The type of construction was used for the first time in New York schools two years previous, in P. S. No. 29. The alternate concrete design, based on beam and girder construction, adopted for the building, was worked out by me while I was connected with the Truscon Steel Co., in co-operation with their engineering department. Various other concrete alternates were advocated, but our scheme proved to be the most economical and was selected by the contractor. That the selection was right was proved by the fact that subsequently a majority of the twenty odd schools built used the same type, before P. S. No. 50, described by Mr. Seelye was even contemplated.

The contractor for P. S. No. 50, described in the article, became interested in concrete beam and girder type for schools when the matter first came up in connection with P. S. No. 29. In pushing the matter, I received a good deal of assistance and encouragement from him since he saw the possibilities and advantages of this type for school buildings. After securing the contract for P. S. No. 50, the contractor naturally turned to me with the suggestion of working up a proposition of a similar nature as had been used in P. S. No. 29. Mr. Seelye had no connection with the matter until the type of construction was decided upon.

Mr. Seelye claims to have been the first to eliminate the heavy structural steel auditorium girder. This was also done in connection with P. S. No. 29.

With working up the actual drawings I had no direct connection and due credit can be claimed by the designers of the firm for the work performed.

New York, July 8. EDWIN A. FRASER.

[The above letter was submitted to Mr. Seelye and he has replied as follows—EDITOR.]

Sir—I do not think that a rebuttal of Mr. Fraser's statement would add to engineering knowledge or interest your readers. ELWYN E. SEELYE.

New York, July 18.

Cohesion in Earth

Sir—With reference to G. Paaswell's article on earth pressure theory, *Engineering News-Record*, April 21, 1921, p. 682, it appears to me that in deducing a conchoidal fracture surface from the theory of stress he uses the theory illegitimately. It seems to be mechanically impossible for the compression due to weight to cause tension on the planes given. Bursting stress involves a compressive reaction in the surrounding earth, not tensile reaction. Crosthwaite in England and Westerberg in Sweden have found friction angle to diminish with depth, but this is probably a question of water content.

HERBERT CHATLEY,
Shanghai, June 9. Whangpoo Conservancy Board.

Uses for Condemned Wooden Ships

Sir—The decision of Mr. Lasker, the newly appointed chairman of the U. S. Shipping Board, to sell or destroy all the Board's wooden steamers before October 1, has just come to my notice. As it is very unlikely that many of these vessels will be sold, the destruction of the greater portion is to be foreseen and a discussion of means to prevent such total loss should be of interest.

In this connection I would suggest two plans, which to my knowledge have not been previously used or suggested. The first and principal one is the use of these vessels in the building or extension of ocean jetties.

I have had some experience with such work on the coast of the State of Washington, where extensive works of this kind have been constructed at the mouths of the Columbia River and Grays Harbor. The present method consists of constructing pile trestles from which the materials for the mattresses and rock are placed. All this work is done under great difficulties and danger, and very often sections of the trestle are lost through heavy seas. In case of later jetty extensions or in building groins to prevent undercutting of completed sections the rebuilding of the trestle is necessary.

As a substitute for the above method I suggest that, after steamers have been stripped of all salvage material, they may be loaded with rock, after possibly first placing willow mattresses on the bottom of their holds and sinking them in line or in a staggered position along the line of the proposed jetty, extension or groin. If the amount of rock thus placed be insufficient, additional quantities could be put in place by the use of cableways suspended from the masts of the vessels. Or it is very probable that additional rock could be deposited from barges laid alongside the sunken vessels on the leeside.

Another use for these vessels, though more limited, would be their employment in establishing foundations for lighthouses on sandy bars in exposed locations.

Paris, France, July 8. HARRY W. ROETZKES.

HINTS FOR THE CONTRACTOR

Built-Up Timber Sections Form Track for Steam Shovel

BY C. W. GEIGER
San Francisco, Cal.

PIECES of timber bolted together to form sections make a convenient track for steam shovel use and can be handled by the shovel itself as shown in the accompanying illustration. Each section is made up of six pieces of 6 x 8-in. timber and two shorter pieces of 2 x 8-in. plank. The planks are put in the center leaving a central hole for the passage of a chain without damaging the timbers. A hole cut in the timbers for this purpose would, of course, reduce the salvage value of the timber. The sections are ordinarily delivered to the job by a motor truck from which they are unloaded by the shovel itself, using a chain passed through the center hole and caught in the teeth of the bucket. When placing the sections in position on the ground it is more convenient to attach the chain to the rear of the bucket so the section can be placed well back toward the shovel wheels.

TRACK SECTIONS AS THEY ARE UNLOADED FROM TRUCK

Railroad Crossing Made Up on the Job With Oxy-acetylene Torch

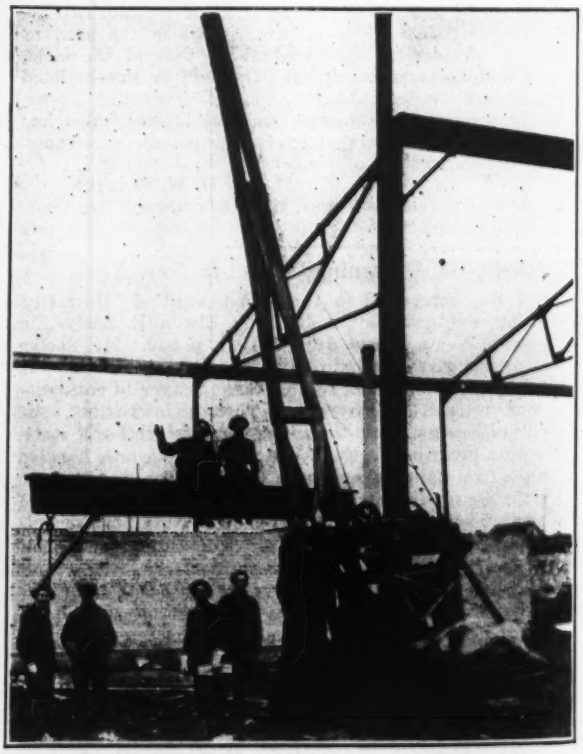
IN LAYING out the industrial track to be used in the construction of the Hetch-Hetchy dam for the San Francisco water supply, a crossing was built up on short notice with the aid of an oxy-acetylene torch. This was considered advisable because the job is about 120 miles by rail from San Francisco and the delay and cost incidental to getting the necessary special work was not warranted by the limited service and light traffic for which the crossing was being built. The gage is 36 in. and the rails weigh about 40 lb. per yd.

INDUSTRIAL RAILROAD CROSSING MADE UP ON THE JOB

The rails on the main line were cut only in the head (to make a flangeway for wheels on the crossing track) leaving web and flange continuous. Two short pieces of rail were then cut with the required angle on each end to fit in between rails on the main line. Adjoining rail ends on the crossing track were likewise cut on the proper angle. Four angle irons were used at each rail intersection. As a means of stiffening the crossing and at the same time providing a guard rail, short lengths of rail were cut so that when laid on one side, as shown in the accompanying illustration, they would fit in between the main line rails, head against web.

Power Winch and A-Frame Transform Bucket Loader Into Crane

SIX men with the aid of the machine shown in the accompanying picture, completed a nine-day job with two lean-to trusses and one apex truss in less than a week's working time at the plant of the Barber-Greene Co., Aurora, Ill. Previous to the arrival of the structural iron workers a Barber-Greene self-feeding bucket loader was fitted up as a stiff-leg crane. The bucket elevator was removed and a power winch installed on top of the frame which houses the gasoline engine. At one side of the frame an A-frame was firmly attached with a platform at the opposite side weighted with sacks of sand to form a counter-balance. This measured 32 ft.



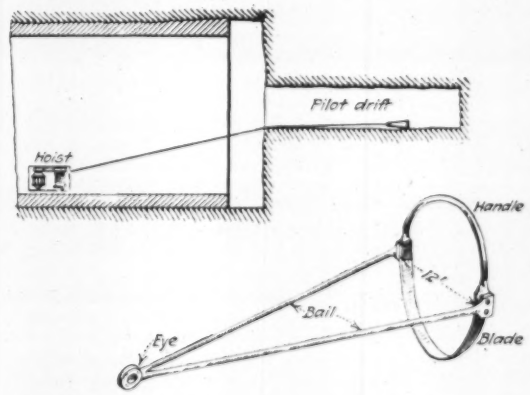
SELF-FEEDING BUCKET LOADER RIGGED AS STIFF-LEG CRANE

from the ground. A pole was lashed to the A-frame to give the boom a height of 50 ft. in order to put up the apex trusses. The original drive by crawlers did not need to be altered, and by means of the accurate control possible with the crawlers, no difficulty in maneuvering was experienced even though it was not possible to raise and lower the boom. Power was furnished by a 25-hp. gasoline engine.

The bridgemen who worked with the machine were enthusiastic about its performance. The foreman, Charles Herbert, declared that it was better than a mule traveler and much faster than a gin pole. Six men, including the operator of the machine, comprised the crew. The five structural iron erectors were working for the Earl Mosely Construction Co.

Power Draw-Knife Digs Detroit Sewer Tunnels

A DRAW-KNIFE pulled by cable from a single-drum electric hoist is proving highly successful on a number of the tunnel contracts for the new sewer system for Detroit, Mich. As observed on tunnel for a 11½-ft. brick sewer, a 10-hp. electric hoist was located as shown by the sketch. The procedure is, at night, to drive the pilot drift about 30 in. wide and 48 in. high. The length of the drift is about the regular



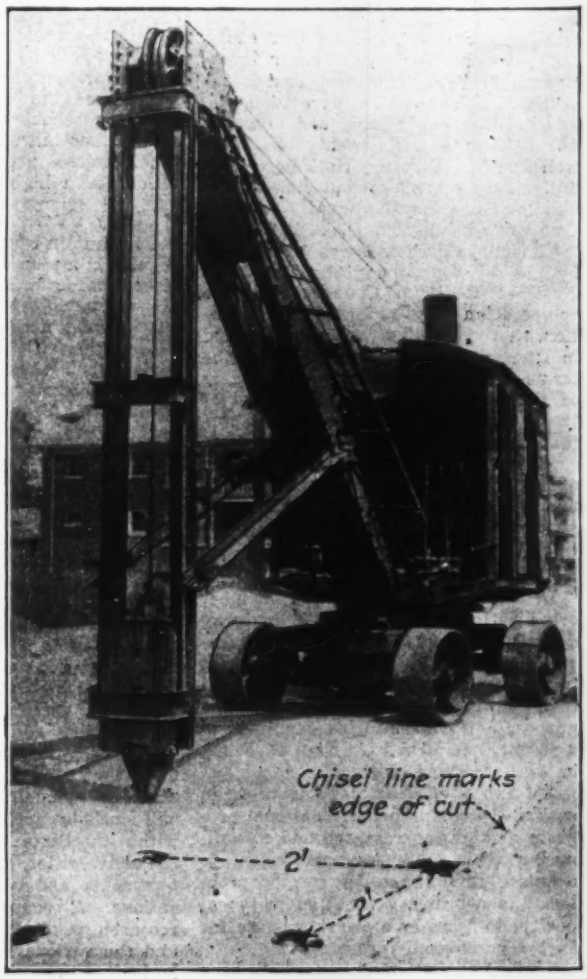
TUNNEL EXCAVATION WITH POWER DRAW-KNIFE

daily advance of the tunnel. Two men, a miner and a mucker, drive the drift. On the day shift, the drift is enlarged by making cuts with the draw-knife, or taking off shavings from the sides and bottom, the full length of the drift. One man operates the knife, carrying it forward as the cable is payed out and guiding its cut as the cable is handed in.

As indicated by the sketch the knife is an oval ring with the top part round and wrapped with cloth to form a handle and the remainder of the ring a flat blade of tool steel. To the opposite sides of the ring are attached two bail rods meeting in an eye to which the pulling cable is hooked. The knife cuts the clay in long ribbons which break as they fall; the muckers load the pieces with their hands. The knife works excellently in the smooth Detroit clay and best when this clay has enough sand to break up well as it is shoved down. With the knife, two miners and six muckers take the place of six miners ordinarily employed in hand excavation, with a material reduction in wages and an increase of 25 per cent in output. The hoist and knife cost about $700.

Pavement Breaker Improvised from a Steam Shovel

AN ERIE steam shovel equipped with hanging leads and a pile hammer, with a chisel blade, is being employed in street railway track construction in Detroit, Mich., to break up the old pavement over the 16½-ft. trench required for the new structure. As indicated by the illustration the breaker is used to punch holes about 2 ft. apart, with such shattering as may result, and not to chop up the pavement completely into small



PAVEMENT BREAKER ATTACHMENT FOR STEAM SHOVEL

fragments. A steam shovel follows the breaker and tears out and loads the old pavement into trucks. If the asphalt surface is in good condition it is removed and reclaimed for reuse by the city street department, but otherwise it is loaded, with the concrete base and other excavated material, into trucks and wasted. The new construction is being performed by the Department of Street Railways under the direction of H. P. Hevenor, construction engineer, with W. R. Dunham as assistant in direct charge.

NEWS OF THE WEEK

New York, July 28, 1921

To Co-ordinate Highway Research Work

Prof. W. K. Hatt Chosen by National Research Council to Direct Comprehensive Program

The advisory board on highway research of the National Research Council has engaged, as director, William Kendrick Hatt, professor of civil engineering and director of the materials testing laboratory, Purdue University, Lafayette, Ind. His work as an investigator in organizing the timber investigations of the U. S. Forest Service, and in other engineering and scientific fields for the past twenty years, is well known. Director Hatt began his duties July 1, with headquarters in the building of the National Research Council, Washington, D. C.

The advisory board was established by the division of engineering of the National Research Council, with the co-operation of Engineering Foundation, as the result of a conference held in New York last November. By the terms of the by-laws the membership of the advisory board is composed of those organizations of national importance interested in design, construction, economics, maintenance and financing of highways, in materials and equipment therefor, and in vehicles used on highways.

Objects of Board

In addition to the fifteen member organizations, thirteen state highway departments and more than forty universities have signified their interest in the work of the advisory board and their willingness to co-operate. The purposes of the board, as explained in a recent statement by Alfred D. Flinn, its vice-chairman, are:

To assist existing organizations in outlining a comprehensive national program of highway research and co-ordinating their activities thereunder; to organize committees for specific problems; to act in a general advisory capacity; to serve as a clearing house for highway research information.

Three technical committees have been at work for a number of months. These are (1) On economic theory of highway improvement, Prof. T. R. Agg, Iowa State College, chairman; (2) on character and use of road materials, H. S. Mattimore, engineer of tests, Pennsylvania State Highway Department, chairman; and (3) on structural design of roads, A. T. Goldbeck, engineer of tests, U. S. Bureau of Public Roads, chairman.

The executive committee of the advisory board has the creation of additional committees under advisement, such as committees on vehicle design as related to a road, economics and cost of transport, financing highway improvements, traffic studies, and organization of construction plants.

Director Hatt's work is expected to stimulate experimental work. In consultation with the advisory board he will prepare a comprehensive plan of the field of highway research, including economics, design, construction and administration, and will arrange a program of committee work for those fields that need to be occupied.

The personnel of these committees will include active research workers within the State highway commissions, the universities, the governmental departments and other research organizations. A census will be taken of the research work completed and current, and the various research agencies will be invited to co-operate in an attack on those urgent problems upon the solution of which the future success of highway transport depends.

The program for highway research will not be limited to problems concerned with the construction and maintenance of roads from the ordinary engineering standpoint. It will also consider problems of economics of transport upon highways in relation to other transport agencies, relation of design of vehicles to character of road construction, and administration, involving traffic regulation, fees and maintenance.

Prospects of New Federal-Aid Road Funds Appear Slim

(Washington Correspondence)

Senator Townsend, chairman of the committee on post offices and post roads of the Senate, practically is convinced that the appropriations committees will not entertain any proposition to grant additional funds for federal-aid highway work. Despite the fact that no appropriation probably will be authorized in the near future, Senator Townsend has called upon the committee to begin work on the highway bill which has passed the House. It is his expectation that the committee will amend that bill so as to embody in it the interstate road plan and the provision for a highway commission.

Study Pueblo Reservoir Sites

Cooperation of the U. S. Reclamation Service in a plan to construct a storage reservoir for irrigation water 8 miles above Pueblo, Col., to safeguard the city against floods is being sought in Washington. Congressman C. B. Timberlake has advised the Denver Civic and Commercial Association that the Reclamation Service is now investigating the project. A survey was made several years ago.

Detroit Gets Estimate for Water From Lake Huron

Since additional water will be needed for Detroit almost as soon as the 400-m.g.d. filtration plant now under construction is completed, Gardner S. Williams, Ann Arbor, Mich., has made a report on a supply from Lake Huron. A ridge between the lake and the city would necessitate pumping. Of two possible routes for a conduit the shortest one, 49½ miles in length, would have a maximum lift of 73 ft., the final elevation being 40 ft. above the source. The second and preferred route is 55 miles long, with a maximum rise of 170 ft., 22 miles from the lake, where a 2,000-m.g. reservoir would be located, permitting gravity flow from the remainder of the distance. Two 7-ft. concrete lined steel pipe lines are proposed for the 22-mile mains to the reservoir and a 10-ft. concrete-lined steel gravity line to a 400-m.g. service reservoir near the city. It is estimated that 800 m.g.d. will be required by 1939 if the population increases at as high a rate as it did from 1910 to 1920.

Lake Huron water shows only one-twentieth as many bacteria as the present supply and half as many as B. Coli.

The $30,000,000 estimated cost is made up as follows: Intake $1,025,000; pumping station, $2,108,000; force mains, $9,376,000; storage reservoir, $2,320,000; gravity conduit, $8,080,000; service reservoir, $1,620,000; contingencies and engineering at 20 per cent, $5,471,000.

Other plans are being studied by the water commission since further extensions of the plant at the present site are not considered advisable because of the concentration and congestion of force mains in the streets leading from the station.

Holland to Visit European Tunnels

The New York and the New Jersey tunnel commissions last week concurred in a resolution authorizing Clifford M. Holland, their chief engineer, to make a trip to Europe for the purpose of inspecting vehicle tunnels and securing at first hand data which may be employed to advantage in the final details of design and operation of the Hudson River vehicular tubes, contracts for which are scheduled to be advertised next September. Mr. Holland will devote particular attention during his trip of observation to matters of lighting, interior finish, general operating methods, and the handling of traffic. He will probably sail from New York early next month and is planning to include London, Glasgow, Paris and Hamburg in his itinerary.

War Finance Corporation May Resume Railway Loans

In response to recent inquiries concerning the War Finance Corporation in relation to the railroad situation, Eugene Meyer, its managing director, stated that he had nothing to say beyond the fact that there has been some general discussion of the possibility of Congress authorizing the corporation to resume the making of advances to railroads, or to the Director-General of Railroads in connection with his advances to the railroads. He pointed out that during the war the corporation, under section 9 of the war finance corporation act, had authority to make advances to the railroads under federal control "for the purpose of making additions, betterments, or road extensions to such railroad"; that this authority has now expired, and that it would be a question of policy for the Congress and the Administration to determine whether or not, from the point of view of the national welfare, it should be revived.

ADVANCES TOTALLED $205,000,000

"The War Finance Corporation," said Mr. Meyer, "made advances to the railroads during the administration of Director General McAdoo and later under the administration of Director General Hines. The total amount advanced was $205,000,000, all of which, with the exception of about $45,000,000, has been repaid. Some of the loans of the corporation were made to the railroads for the purpose of enabling them to repay the advances made to them by Director General McAdoo, thereby putting the Railroad Administration in funds. Large advances were made during the period from March to July, inclusive, 1919—subsequent to the failure of Congress to pass the railroad appropriation—upon the security of certificates of indebtedness issued by Director General Hines, and were all repaid when Congress met in extra session and passed the railroad appropriation. Among these advances was one for $50,000,000 to the Director General of Railroads."

Two propositions for wheat business are now under consideration by the War Finance Corporation, according to Mr. Meyer. One involves nine million bushels and the other an uncertain amount but probably as much or more.

The War Finance Corporation, Mr. Meyer stated, has not sought any extension or prolongation of its powers, but, if Congress desires the corporation to resume activity in connection with railroads and to broaden its powers for agricultural financing, it will respond.

Drainage Congress at St. Paul

The National Drainage Congress is to be held at St. Paul, Minn., on Sept. 22 to 24. E. R. Jones, state drainage engineer of Wisconsin, Madison, Wis., is acting president on account of the death of Edmund T. Perkins; L. K. Sherman, Chicago, is director.

Making Public Health Survey of Tippecanoe County, Ind.

A public health survey of Tippecanoe County, Ind., is being made during July and August by Dr. Murray P. Horwood of the Department of Biology and Public Health of the Massachusetts Institute of Technology. The survey includes water supplies, sewerage and sewage disposal, refuse collection and disposal, milk supply, sanitation of food stores and restaurants, housing, school sanitation and hygiene, organization and activities of the health department, vital statistics, anti-tuberculosis activities, hospital facilities and an analysis of the city budget. According to Dr. Horwood: "The purpose of the survey is to ascertain exactly the condition of the factors affecting the public health, and to formulate a program for the improvement of the public health based on the findings of the survey. The aim is to attack the tuberculosis problem not only by considering the disease itself, but by improving the general health of the community." The work is being done under the auspices of the Tippecanoe County Tuberculosis Association. The county named includes the city of Lafayette and the town of West Lafayette, the home of Purdue University.

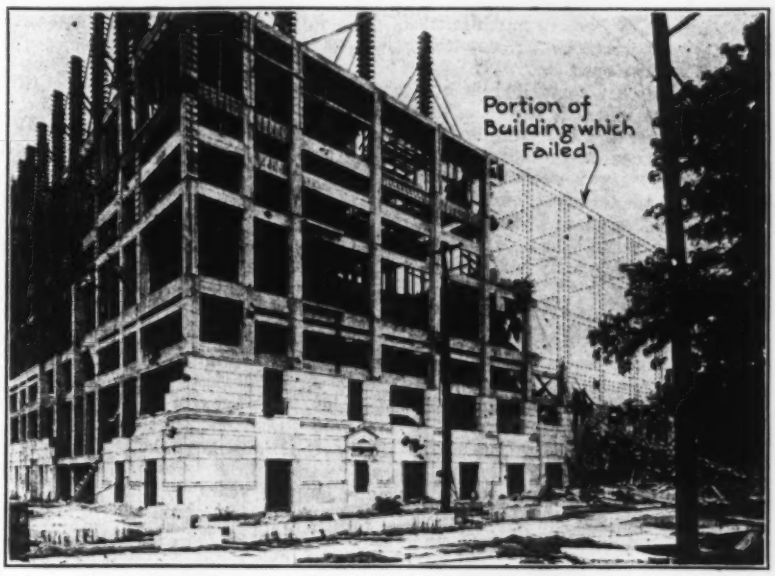
Denver Commerce Body to Select Water Engineer

The Denver Civic and Commercial Association has selected T. B. Stearns, chairman; Major L. D. Blauvelt, Richard A. Parker, Arthur Ridgeway, H. S. Sands, D. G. Thomas and T. L. Wilkinson as a committee of engineers to recommend to the Municipal Board of Water Commissioners the name of "an engineer of national repution to make a survey of Denver's water plant and its needs".

Masonic Temple Falls During Construction

Reinforced Concrete Structure at Salina, Kan., to Cost $800,000, Nearly Completed When Failure Occurs

About four-fifths of the $800,000 reinforced-concrete Masonic Temple at Salina, Kan., collapsed at 10 a.m. July 11. The building is 167½ x 125 ft. and 88 ft. high, with five stories. At the time of the failure the structural work was completed with the exception of the roof. No disturbance of forms had taken place in the east portion, under the auditorium ceiling, where the failure started, and no concrete had been poured in the supporting members since the first week in June. Shoring was being erected for the roof slab.



COLLAPSE OF MASONIC TEMPLE AT SALINA, KAN., DESTROYED FOUR-FIFTHS OF STRUCTURE

Workmen discovered undue buckling of the shores about an hour previous to the accident and reported this to the foreman, who immediately started eighteen or twenty carpenters strengthening the shores. A crash above them gave sufficient warning so that all the men got out except two on the roof. These men rode down with the wreckage but escaped with minor injuries, although it took four hours to release them.

The Condron Co., Chicago, is investigating the disaster for the owners. T. L. Condron states that the Eberhardt Construction Co., which had the contract, apparently had exercised more than usual care in the handling of material and placing of forms; also that the appearance of the concrete is good, but samples have been taken for test.

States Get 30,303 Army Trucks

A total of 30,303 motor vehicles have been transferred by the War Department to the Bureau of Public Roads for distribution among the states for road building, the Director of Sales reports.

Bolivia Retains Lavis to Advise on New Railway

F. Lavis, consulting engineer of New York City, has been appointed consulting engineer to the Bolivian Government and the Ulen Contracting Co. in connection with the construction of the railway between Atocha, Tupiza and Villazon on the Argentine frontier. By the construction of this line there will be established continuous rail communication over lines of the same gage between Buenos Aires and La Paz, a distance of nearly 1,500 miles, and by connection to the Antofagasta railway and the railways of Peru two additional transcontinental routes across the Andes will be developed.

The section to be completed is approximately 126 miles in length. The gage is 1 meter (3 ft. 3⅜ in.) and it is proposed to use 60-lb. rails. Part of the work is very heavy and 3 per cent gradients and curves of 100 m. radius will be required. Mr. Lavis according to present plans will leave New York for Bolivia early next month.

Pennsylvania Plans Widening of Important Highways

While no immediate construction activities will result, the State Highway Department of Pennsylvania for the last two years has been making a study of traffic conditions on thoroughfares leading to important municipalities and eventually steps will be taken to increase the width of the arteries leading into the larger cities of the state. At the instance of the highway department the 1921 legislature enacted legislation which received the approval of the Governor and which will give the state highway department power to extend the width of important thoroughfares so that they will be adequate for the safety of road users.

It is not the purpose of the department, according to a recent official statement, immediately to widen these highways, but merely to make a survey of possible future traffic. The department hopes by this procedure to save the enormous expenditure which will necessarily be entailed in widening arterial roadways after improvements have been completed. The recent legislature gave the department authority to extend the width of highways to 120 ft. The great increase in motor vehicle traffic within the limits of the larger municipalities of Pennsylvania, department officials believe, will eventually necessitate the building of thoroughfares skirting these municipalities and wide enough to accommodate several streams of traffic going in both directions. Within a few years, it is predicted, it will be unwise to send heavy trans-Pennsylvania traffic into Philadelphia and Pittsburgh, for example, inasmuch as addition of this traffic will add to the congestion of the down-town districts. Consequently, the highway department is convinced that wide roads must be provided around the larger cities so that traffic may be accommodated.

Two Large Bridges Opened to Traffic

On July 2 the new bridge over the St. Johns River at Jacksonville, Fla., a steel structure containing a vertical lift span, was opened to traffic. The structure includes nineteen spans, the longest of which is the 188-ft. lift span. Including approaches, the structure is 3,800 ft. long, and cost nearly $2,000,000. On the same day the Mound St. bridge across the Scioto River at Columbus, O., built to replace a bridge destroyed by the 1913 flood, was opened to traffic. This is a concrete arch bridge 1,050 ft. long, of nine spans, which cost about $600,000.

Tennessee Governor Appoints Engineer License Board

Governor Taylor of Tennessee has just appointed the state board of architects and engineering examiners called for by the registration law passed last April. The board is composed of three architects and three engineers, as follows: N. W. Daugherty, Knoxville, civil engineer (six-year term); Prof. C. S. Brown, mechanical engineer, Vanderbilt University, Nashville, six years; A. L. Dabney, civil engineer, Memphis, four years; W. G. Sears, architect, Chattanooga, four years; Henry C. Hibbs, architect, Nashville, two years; B. S. Cairns, architect, Memphis, two years.

The appointment of this board marks the final step in the crusade of Tennessee engineers and architects for the passage of a registration law. The movement was begun in the fall of 1920 by the Engineers' Club of Memphis, when a committee, consisting of C. E. Shearer, A. L. Dabney, and Ralph Bosard, was appointed.

The law, as passed, follows the general features of the Engineering Council law, but the law makers cut out the requirement for registration of land surveyors largely because of objection from the rural sections of the state.

The law provides that, within one year after its passage, persons practising architecture or engineering in the state shall be required to submit evidence of qualifications to practice and shall be registered. The provisions of the act are carried out by the board of examiners appointed by the Governor. Board members are required to have had ten years' experience, five years in responsible charge of work, to be a citizen of the United States and a resident of Tennessee and to be thirty-five years of age. The license fee is $25.

Consulting engineers from out of the state associated with an architect or engineer in the state are exempted, provided they can qualify for such service in their own state.

Corporations or partnerships may practice engineering or architecture provided the person or persons connected with such corporation in responsible charge of such practice is or are registered as required.

Department of Public Works for California

In accordance with measures passed at the last session of the California legistlature, the state board of control has completed the reorganization program which was called for in the interests of economy and efficiency in government affairs. The new program provides for seven departments under which all work of the state will be done and which will replace eighty or more existing state agencies. Under the new program, which is to go into effect July 30, chief responsibility is vested in a department of finance. Other departments are: Civil service, institutions, industrial relations, public works, agriculture and education.

For the present it was not considered feasible to make an immediate and absolute change of the full scope implied by the naming of these several departments. Existing departments were rearranged, for the most part, so as to conform to the new plan and to interfere as little as possible with the present personnel and machinery.

The department of public works, for example, will have as its director or senior engineer the chief engineer of the state highway commission, who will add the new duty to his present work without change in salary. The department will have five subdivisions as follows: Highways, engineering, water rights, land settlement and architecture. The state engineer retains his title and continues his present duties under the general jurisdiction of the department.

To Report on Lake Michigan Interstate Harbor

Bills providing for an interstate commission to report on the feasibility of a harbor at the Illinois-Indiana state line on Lake Michigan (to be called Illiana) and in Wolf Lake have been passed by the legislatures of both Illinois and Indiana. The commission is to be composed of two members for each state and a fifth appointed by the Chief of Engineers, U. S. Army. The Indiana bill provides that the Indiana members shall be appointed by the governor, but the Illinois bill specifies that the members shall be the director of the state department of public works and buildings and the superintendent of the division of waterways of that department.

Each bill appropriates $25,000 for the purposes of the commission and provides for the employment of engineering, legal and other assistance. The Indiana bill requires a full report to be made to the next general assembly of the state, but the Illinois bill does not specify the "next" assembly. This project was described in *Engineering News-Record* of Jan. 20, p. 120, but on the map the name of the proposed harbor was given incorrectly as "Indiana" instead of "Illiana." This project was suggested originally by Colonel W. V. Judson, Corps of Engineers, U. S. Army.

To Vote on $4,000,000 Filter Project at Buffalo

At the election next November the voters of Buffalo will pass on a proposal to issue bonds for a 160,000,000-gal. water filtration plant at an estimated cost of $4,000,000, which shall not exceed $4,500,000. The proposed plant is to be located just south of the Colonel Francis G. Ward pumping station. The City Commission has appropriated $10,000 for investigation preliminary to the design of the proposed filtration plant, but no work will be done on the detailed plans until after the results of the November election are known. George C. Andrews is water commissioner of Buffalo, and Arthur W. Kreinheder is commissioner of public works.

Federal Co-operative Reclamation Act Favorably Reported

On June 29 the Senate Committee on Irrigation and Reclamation favorably reported Senator McNary's bill (S. 2170) introduced June 27, "to encourage the development of the agricultural resources of the United States through federal and state co-operation, giving preference in the establishment of rural homes to those who have served with the military and naval forces of the United States." The bill provides for a revolving fund totaling $250,000,000 to be built up at the rate of $20,000,000 for the first year, $35,000,000 the second year, $45,000,000 the third year, and then $50,000,000 for each of the three succeeding years.

Although the title of the bill specifies federal and state co-operation, state action will be through the agency of legally organized reclamation districts. These districts are to be initiated in co-operation with the Secretary of the Interior and the validity of their organization must be confirmed judicially before the Secretary enters into a contract with the districts for the reclamation of lands. Bonds up to the estimated cost of the reclamation work, plus interest on the bonds during construction, and 2 per cent additional to pay various incidental expenses, are to be issued by the district and deposited with the Federal Farm Loan Board for disposition. The bonds are to run for periods of not over forty years and to bear interest at a rate to be fixed by the Secretary of the Interior, not to exceed 5 per cent. According to the report of the Senate committee it is expected that the district bonds will not be sold until "the land within a project will have attained sufficient value to warrant" their sale to the public. When such a sale is effected the money thus raised goes back into the revolving fund. The committee estimates that within the twenty years prior to the time that the Reclamation Service must begin repaying the proposed $250,000,000 fund the turnover of money provided by the districts, including interest, will amount to something over $1,000,000,000.

Under the bill ex-service men and women are to have the preference of purchase of lands thrown open to sale for a period of sixty days. The maximum farm unit under the bill will be 160 acres. Privately owned lands in excess of this unit are to be sold.

U. S. Public Health Engineer Urges Filters for Milwaukee

Another report on Milwaukee's water supply urges filtration without delay. R. E. Tarbett, associate sanitary engineer, U. S. Public Health Service, is the author of the report, recently made public although dated May. In the main his conclusions agree with those of Harrison P. Eddy, given in *Engineering News-Record*, July 7, p. 26.

Mr. Tarbett's conclusions are: Chlorination is not now efficient, due to rapid changes in the bacterial content of the water. After the sewage disposal plant is built there will still be pollution, varying in intensity and therefore difficult to control by chlorination. Filtration is necessary to obtain a clear supply. Colloidal chemistry may help control the coagulation process but it will not materially effect the design. Experiments on coagulation are advisable. He urges that the city proceed along lines recommended by J. W. Ellms; that the U. S. Public Health Service cooperate in making coagulation experiments at Milwaukee, and do so at once so as not to delay construction; that the consulting engineer who supervises the preparation of filter plans for the city represent the city in these experiments and that the experiments form a part of a larger co-operative investigation to be be carried on by the Service and many coagulation and filter plants over the country.

Coincident with this report was another by Mr. Tarbett outlining the proposed co-operative experimental work at Milwaukee, Cleveland, Cincinnati, Louisville, Minneapolis, St. Louis, New Orleans, Shreveport, La., Birmingham, Ala., Columbus, Ga., Wilmington, N. C., Baltimore, Wilkinsburgh, Pa,. South Pittsburgh, Pa., New Castle, Pa., and Bangor, Me. The object would be to learn the effect of hydrogen-ion concentration in connection with coagulation and chlorination processes to the end that better methods of control and efficiency might result.

California Highway Bonds Find Ready Market

An offering of $4,878,000 of 5½-per cent California Highway bonds made on July 15 was oversubscribed on the day offered. The bonds sold above par, the total premium being $19,550. The speedy sale as compared with the great difficulty or inability to sell bonds in previous yars is due to the higher rate of interest on the issue recently sold. Interest rates are now determined for each issue according to market conditions by a commission, the formation of which was announced in *Engineering News-Record*, Nov. 11, 1920, p. 962.

Montclair, N. J., Commission Acts on Sewage and Water

The town commission of Montclair, N. J., on July 21 voted 4 to 1 to contract with the Passaic Valley Sewerage Commission for the disposal of the sewage of Montclair through the Passaic Valley trunk sewer, treatment works on the Newark Meadows and tunnel beneath Newark Bay and the Bayonne Peninsula to an outlet in Upper New York Bay near Robins Reef. At the same time the commission voted unanimously to offer the Montclair Water Co. $700,000 for its distribution system within the town of Montclair, in accordance with a valuation of Clyde Potts, consulting engineer, New York City.

The total estimated cost for Montclair to enter the Passaic Valley trunk sewer is $1,739,055, including deferred interest (explained below) and a supplementary outlet sewer to the trunk sewer.

Items in Total Cost

Montclair's share of the cost of the trunk sewer and disposal scheme is $1,234,055, of which $947,670 is for the town's proportion of the $18,000,000 of obligations already incurred by the sewerage commission and $205,271 is interest computed to Feb. 1, 1922, on Montclair's share of original contracts entered into years ago, totaling $11,250,000 — Montclair having proposed heretofore to dispose of its sewage independently. Another item in the total of $1,234,055 is $81,114 as Montclair's estimated share of completing the Passaic Valley project in excess of the $18,000,000 of expense and commitments already named.

It is estimated that it will cost Montclair $330,000 to construct a relief sewer to the Montclair-Bloomfield outlet sewer and $175,000 for a supplementary sewer paralleling the Orange-Montclair-Bloomfield outlet sewer to the present river, Montclair having contract rights in the joint outlet for a capacity of only about 5,000,000 gal. a day.

May Acquire Distribution Mains

Montclair has not yet provided funds for either the sewage disposal or water-supply project. As to the latter, under state legislation, the town proposes to offer the Montclair Water Co. the $700,000 for its distribution system already named, and in case that offer is not accepted to take the distribution system by condemnation. The company's book value for the distribution system is said to be $825,000. If the distribution system is acquired, it is the intention of the Town Commission to obtain a new water supply. Its present supply is from the Little Falls filtration plant of the Montclair and East Jersey Water companies. Mr. Potts stated in his report to the commission that Montclair might possibly arrange for a supply from either the Newark pipe line from the Pequannock River or the Jersey City conduit from the Rock-

away River, both of which pass through the town, or it might get water from the Wanaque River development for the city of Newark, now being carried on by the North Jersey District Water Supply Commission.

Dr. James T. Hanan is Commissioner of Streets and Public Improvements and William F. Bates is town engineer of Montclair.

Gans Zeolite Water Softening Patents Upheld

The Gans patent for water softening by the use of zeolites has been upheld by the U. S. Circuit Court for the Western District of New York in a decision handed down on June 15 in The Permutit Co. against the Harvey Laundry Co. and the Refinite Co. The process and apparatus, as described in U. S. Patent 1,195,923, issued Aug. 22, 1916, to Dr. Robert Gans, of Pankow, Germany, covers water softening by passing water through a layer of zeolites or hydrated alumino-silicates, resting on a layer of sand and quartz, and the regeneration of the exhausted zeolites by passing through them a solution of salt (actually common salt, or sodium chloride). The defendants alleged lack of novelty, foreign publication, etc. The court upheld the patent on the ground of infringement and decreed an injunction and an accounting with costs to the plaintiff. Fuller particulars may be obtained from the Permutit Co., 440 Fourth Ave., New York City.

PERSONAL NOTES

THEODORE HORTON, for many years chief of the division of sanitary engineering of the New York State Department of Health, became chief sanitary engineer in the Department of the State Engineer of New York on July 1. The change results from recent legislation virtually abolishing the division first named and transferring its work, so far as relates to passing on plans for sewerage and sewage disposal, from the State Department of Health to the State Engineering Department.

J. C. GARDNER has been appointed city engineer of Niagara Falls, Ont., Canada.

E. W. BALDWIN, resident construction engineer for the Sinclair Refining Co., Coffeyville, Kan., after a vacation in Colorado and Yellowstone country, will become an active member of the Mid-West Engineering Co., Coffeyville, Kan.

ARTHUR H. MORRISON, formerly with the Aberthaw Construction Co., Boston, Mass., has become associated with the Moulton Engineering Corp., Boston Mass.

CALEB M. SAVILLE, manager and chief engineer of the water department of Hartford, Conn., has been appointed a member of the Hartford Meadows Development Commission, authorized by the last legislature to reclaim a large area of land from floods by building dikes at an expense of $2,000,000.

R. A. CATTELL, formerly on the technical staff of S. Pearson & Son, London, England, in connection with the work of this firm as petroleum development managers for the British Ministry of Munitions of War and later engineer and chief of the construction department at St. Aimé, Algeria, Africa, of the Société d'Etudes de Recherches et d' Exploitation des Pétroles en Algérie, for whom S. Pearson & Son are technical directors, is now in the service of the U. S. Bureau of Mines in charge of the field office at Shreveport, La. He is the co-author with H. W. Bell of a report on the Monroe gas field in northern Louisiana which is now being published by the Conservation Commission of the State of Louisiana.

NELSON L. PROTHEROE, formerly superintendent for Villadsen Bros., Inc., general contractors, Salt Lake City, Utah, is now superintendent for the Lynch-Cannon Engineering Co., engineers and contractors, Salt Lake City, and will be connected with construction work in the Denver district.

J. PAUL BLUNDEN, formerly county engineer of Boone County, W. Va., has been appointed assistant division engineer, West Virginia State Road Commission, with headquarters at Martinsburg.

ROBERT L. E. WARD, municipal and civil engineer, formerly of Great Falls, Mont., has been made manager of the general engineering office recently opened by the Weiland Engineering Co. in Canon City, Col.

PROF. CHARLES A. HOLDEN, director of the Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H., has been appointed by Governor Brown a member of the commission for the conservation of water power in New Hampshire. He was the correspondent for the State of New Hampshire for the water conservation committee of Engineering Council.

FREDERICK J. TROWBRIDGE, recently with Hugh L. Thompson, consulting engineer, has opened an office for the practice of civil engineering and surveying in Waterbury, Conn., and will specialize in plans, specifications, estimates, construction engineering and supervision, property and quantity surveys, landscape and industrial plant work.

A. H. OXHOLM, for the past 18 months European manager of an American firm of lumber exporters, has been designated by the Secretary of Commerce to be chief of the newly created lumber division of the Bureau of Foreign and Domestic Commerce.

RAY SPERR, county engineer, Keweenaw County, Mich., has resigned to accept a position with the Wisconsin State Highway Department.

VICTOR M. SUMMA, formerly in the service of the American Brake Co., St. Louis, Mo., has opened an office as general consulting engineer in St. Louis.

BURTON HAMILTON, formerly assistant city engineer, has been appointed city engineer of Alameda, Cal.

ROBERT S. HARSH of Alliance, Ohio, has been appointed state architect and engineer of Ohio and will be connected with the department of highways and public works.

BATCHELDER & SCALES, Indianapolis, Ind., is a new architectural and engineering firm organized recently by Ralph J. Batchelder, formerly designer for Allen & Collens, Boston, Mass., and Holebird & Roche, Chicago, Ill, and by Walter H. Scales, formerly chief designer of the Lackawanna Bridge Co., Buffalo, N. Y. Both have recently been partners of the firm of W. E. Russ & Co., Indianapolis.

THE ELCON ENGINEERING CO. has opened offices in Columbus, Ohio, to engage in general contracting and engineering, specializing in elevating and conveying equipment. E. S. Hetrick, president, has been connected with the engineering department of the Jeffrey Manufacturing Co., Columbus, for about 13 years.

OBITUARY

JOSEPH HANSON, contractor of Tacoma, Wash., recently committed suicide in that city. He had been identified with building work in Tacoma for 17 years.

ADOLPHO OLIVERAS, contractor, died in Santa Monica, Cal., July 3. He was 66 years of age. Most of the highways in the Palisades district of Santa Monica and many of the coast roads were constructed by him. He also built the canals in the city of Venice, Cal.

R. H. GILLESPIE, president of the Traylor-Dewey Contracting Co., Allentown, Pa., died July 15, at White Lake, Sullivan County, N. Y. He was born in New York City in 1867 and attended Union College, Schenectady, N. Y. From 1888 to 1894 he was engaged in engineering work with various railroads during which time he was engineer in charge of construction with the Charleston, Cincinnati & Chicago R.R. and with the Little Falls & Dolgeville R.R. In 1896 he became assistant engineer, department of street improvements, 23d and 24th wards, New York City, and later he became assistant engineer, bureau of highways, Borough of Bronx, New York City. He also served as chief engineer of sewers and highways, Borough of Bronx, New York City, for about 12 years. He designed the collapsible forms and traveling concrete plant for the large Avenue A sewer, New York City.

Business Side of Construction

Facts and Events that Affect Cost and Volume

Further Settlements in Wage Disputes Made

Further progress toward settlement of wage disputes in the building industry have been made during the past week. In Rochester, N. Y., there is an indication of an early settlement between employers and employees in some trades, due to the report of the impartial investigating committee and the activity of the mayor of the city. The strike was called on April 1, after the unions had refused to accept a 15 per cent reduction from the general $1-an-hour scale.

In Philadelphia 9,000 carpenters, who have been on strike since May 1, have agreed to a reduction of 22½c. per hour, the old scale being $1.12½. A 44-hour week replaces the 40-hour week and other adjustments in overtime have been made. It is the contention of the contractors that the action of the carpenters will practically bring to a close the strike of almost three months' duration, as only the plasterers and bricklayers remain out. Contractors announce that enough non-union men are available to carry on building.

The San Francisco situation remains unsettled. Press reports are to the effect that all labor unions plan a meeting for Aug. 11, at which time a vote is to be taken on the advisability of calling a general strike as a weapon against the growth of the open-shop movement.

Department of Justice Appeals Bond Premium Case

An appeal has been taken from the recent decision of the Court of Claims to the effect that contractors were allowed reimbursement of the cost of premiums on bond, liability and other insurance. The Department of Justice has just entered an appeal in the Mason & Hanger and the Northeastern Construction Co. cases decided in the contractors favor under date of April 18, 1921. The appeal has been allowed by the court and unless prosecution of it is abandoned at least another year will elapse before final settlement will be possible.

Attorneys for members of the Associated General Contractors of America are confident that the Supreme Court of the United States will uphold the Court of Claims in its decision that contractors should be allowed reimbursement.

California Metal Trades Post Notice of Wage Cut

Notices of wage reductions affecting some 25,000 men in fifty different trades have been posted by all members of the California Metal Trades Association. The reduction is to become effective Aug. 1, and averages about 10 per cent below the scale fixed Nov. 24, 1919.

Irregular Employment, Inefficient Management, Labor Rules Cause Waste in Building

Duplication in Estimating, Accidents, Etc., Secondary Causes, as Found by Committee on Waste Elimination

IN a report made public last week by the Committee on Elimination of Waste in Industry of the American Engineering Council, Sanford E. Thompson, of Boston, who made the investigations in the building industry, asserts that the greatest wastes in building occur through irregular or seasonal employment of skilled mechanics, through inefficient management on the part of the employer, and certain wasteful labor rules. As secondary causes for the waste in construction work are given duplication of labor in estimating and quite often in design, failure of architects to furnish check plans and specifications, and accidents which are particularly important in the building industry because of the extra hazardous nature of the work.

Irregular employment, the report reads, is due to seasonal fluctuations, bad weather, and strikes and lockouts. The point is emphasized in the report that a certain amount of education should be given the public in the matter of making a more equable distribution of construction work throughout the entire year, so that the average working day of the building trades mechanic could be lengthened and his lost time thereby reduced.

Management and Labor Wastes

As to inefficient management, the chief sources of waste in this particular are due to failure to furnish a continuity of employment, failure to plan work in sufficient detail, lack of proper co-ordination of scheduling, purchasing, and delivery with job requirements, lack of standards and adequate cost methods as a means of checking production, high labor turnover, general failure to develop and use a greater amount of mechanical equipment, and waste of material through careless handling and improper plant operation.

The labor regulations which are considered wasteful are classified according to those that (1) require skilled men to do work that could be performed by unskilled men; (2) restrict individual incentive through requiring uniform wages; (3) limit the number of apprentices; (4) reduce excessively the number of working hours; (5) restrict the output by prohibiting the use of labor-saving devices; and (6) impose jurisdictional regulation.

The report cites unemployment figures in the building trade in Massachusetts due to all causes and upon the assumption that these figures are correct and representative of the entire country it is found that if one-half of this unemployment could have been eliminated the value to the building industry, or its wealth to the country would have been increased as follows: 1915, $106,000,000; 1916, $91,000,000; 1917, $113,000,000; 1918, $85,000,000; 1919, $141,000,000; and 1920, $192,000,000. The lost or wasted time exclusive of Sundays, Saturdays and holidays is indicated in the accompanying table

TABLE SHOWING ACTUAL DAYS WORKED IN COMPARISON WITH EFFECTIVE WORKING DAYS POSSIBLE FOR VARIOUS TRADES

Trade	Effective Working Days Possible	Average Days Worked per Year	Per Cent of Time Lost
Plasterers	254	170	33
Painters	254	182	29
Paper hangers	254	182	29
Plumbers	271½	200	26
Iron workers	273½	150	44
Bricklayers	275	182	33
Stone masons	275	185	33
Electricians	280	216	23
Elevator constructors	280	216	23
Engineers	280	200	29
Firemen	280	200	29
Lathers	280	190	32
Composition roofers	280	182	35
Slate and tile roofers	280	170	40
Sheet metal workers	280	185	34
Stone cutters	280	180	36
Asbestos workers	281	185	34
Granite cutters	281	180	36
Cement finishers	281	176	37
Plasterers' helpers	281	180	36
Riggers	281	175	37
Steamfitters	281	180	36
Upholsterers	281	225	20
Laborers	281	277	1
Tile setters helpers	282	200	29
Tile setters	282	200	29
Average	**275**	**189**	**31**

which is compiled from data taken from Philadelphia and vicinity and considered as representative average conditions. The days at work by the accompanying table average 189 per year for the various trades. The average of estimates reported to the committee by various contractors is 210 working days per year, which is considered as nearly right as could be expected. Over half the lost time, it is estimated, is due to bad weather and the balance chiefly in waiting for or looking for work. As an example of the extreme labor turnover which occurs in the building industry, the committee found one man who in the course of five and a half years had worked for 76 different contractors and was hired 108 times. During 1917 this man worked for eleven different contractors and was hired fourteen times in a period of nine months.

As to the means of reducing seasonal employment, the committee finds that, although efforts toward reducing have been local and often spasmodic, recent developments and conferences have shown the possibilities of vast improvement. The means of bringing about a reduction of seasonal employment may be outlined, says the report, by:

(1) Allowing a small margin of profit for both labor and capital during winter months; (2) developing methods of conducting work in cold weather; (3) arranging work to provide indoor operations in cold and stormy weather; (4) organizing a clearing house for co-ordination of activities; (5) increasing the usefulness of employment bureaus, and (6) educating the public.

Adherence to these practices would allow the contractor to figure on work at the same price throughout the year, thus stimulating winter construction and lessening unemployment due to the seasonal feature.

The report emphasizes the necessity for more effective co-ordination of construction activities. The Philadelphia plan, developed by the Building Trades Council under the leadership of D. Knickerbocker Boyd, and which advocates the establishment of a central bureau through which all construction programs in the territory are cleared is cited as a possibility for securing that needed co-ordination.

Strikes Great Waste

"The strike is one of the greatest economic wastes to be found in the building industry," says the report. "If the greatest cause—the demand for an increase in wages—could be eliminated, strikes as a factor of waste would shrink into insignificance," continues the report. "The remedy that suggests itself is co-operation. Management and labor must forget the sore spots of past conflicts and through wholehearted co-operation fix by proper studies a minimum wage to correspond with a standard amount of production, with additional compensation for additional output. This would furnish an incentive to the man and would give recognition to the deserving mechanic. Unions must co-operate to the extent of eliminating the flat rate for all mechanics of a trade and also to the extent of modifying the restriction which forbids mechanics to accept piece work. With definite standards fixed and with the co-operation of both parties fair incentives can be introduced."

The need is also emphasized for the establishment of tribunals for the discussion and settlement of questions concerning wages, hours of labor, working conditions, and the other causes of strikes, lockouts, etc.

As to the waste occurring from bad management, the report asserts that "problems of construction management involve not merely the taking of the contract, the purchase of materials, the engaging of foremen to handle the work. They involve also the arranging of the work of the different trades, the scheduling of the operation and delivery of material, the planning of the work of individuals and groups of workmen, the design and maintenance of the perfect equipment, the maintenance of cost records, the knowledge of what constitutes a day's work, definite policies of employment, and the payment of the workmen in accordance with performance. All of these things are essential in well-managed construction operations."

The report suggests that there are not enough of the effective methods used in construction work which are employed in ordinary factory management; that contractors are too prone to leave the planning of their work to superintendents or often to foremen, and also that rule-of-thumb methods are still largely employed.

The report indicates that one method in which labor turnover could be materially diminished would be through the use of employment managers whose sole duty would be the examination of prospective workmen and co-operation with them while on the job. The theory is advanced that the high percentage of quits on the part of workmen would be materially reduced were the responsibility for hiring and firing employees placed in the hands of a competent and sympathetic employment manager.

Plant Layout

The study of plant layout is another detail of construction management not taken full advantage of, says the report. In such studies it is pointed out that the engineers designing plant layout should co-operate with practical superintendents in order that the layout as designed may be thoroughly practical in operation. "The possibilities of saving by the application of more plant engineering are enormous," says the report, "since the cost of all operations are affected by the equipment used in handling materials, the location of the equipment and the efficiency with which it is utilized. The general failure of the industry as a whole to develop and use a greater amount of mechanical equipment is an established fact. Greater strides have been made in almost every other industry in the application of mechanical means as labor-saving devices and production stimulants. Contractors would do well to realize this and by direct interest develop this side of their industry."

The report asserts that union organization is more essential in building construction work than elsewhere because of the seasonal characteristics and the intermittent employment. It also says that some of the union rules affecting work are justified in furthering the quality and workmanship. However, many are absolutely wrong and uneconomical, asserts the report, and show a lack of recognition of the fundamental principles of economics which require that a man give his best in order to receive a fair return. "Many unions have exceeded the limits of fairness partly because of the leader's lack of appreciation of the fundamental need for high production, have formulated by-laws and in individual cases have formulated demands that have been a tremendous factor directly or indirectly in the restriction of output. This has resulted in increasing cost and reducing demand for building. It represents, in fact, one of the great sources of waste in the building industry. This policy has reacted, resulting in widespread opposition to unions. In fact some of the most successful building contractors employ non-union labor because of their opposition to unjust union rules and requirements." However, it is also emphasized in the report that unions are by no means alone in their restriction of output, but that contractors and builders and supply dealers affect the situation to as great a degree indirectly by maintenance of high prices, collusion in bidding, and unfair practices.

Another fundamental cause for low output, the report asserts, is that all members of unions in the same trade are paid the same wage. Jurisdictional disputes are another cause of restriction of output, though it is pointed out in the report that considerable progress has been made toward decreasing these through the activities of the National Board for Jurisdictional Disputes.

Despite the restrictive action of many of the union regulations, the committee found a growing evidence of a willingness to co-operate inasmuch as it received from many union organizations suggestions as to what could be done to eliminate waste, increase output, and decrease unit costs.

The committee finds that approximately $30,000,000 every year is actually paid to insurance companies for compensation and liability insurance in construction work. Even this figure does not represent the total loss. The report cites the opinion of an unnamed authority to the effect that the actual cost of insurance represents not more than 25 per cent of the total economic loss, which brings the total cost, due to accidents in the construction field, in the vicinity of $120,000,000 per year. The fact that a great many accidents could be avoided is partly indicated in the fact that in New York State, although four times as many people are employed in factories as in building and construction work, during the four years from 1910 to 1914 more fatalities due to accidents occurred in building and construction work than in factories. The fatalities in building and construction work in that period were 1,641 and in factories 1,285. The report also cites the opinion of an official of a large insurance company in which the assertion is ventured that by proper safety measures the waste due to accidents could be reduced 75 to 80 per cent in from two to five years of honest effort, and that construction labor costs could be cut 3 per cent through such measures. Another official estimates from actual accomplishment in safety measures a total of 12,000,000 days per year could be saved the in-

dustry by the application of safety methods.

Other miscellaneous wastes are the delays from lack of plans and details and waste of time, energy, and money through duplication of estimates and of designs.

The committee praises the work that the Associated General Contractors of America are doing in the way of standardization of contracts, ethics, labor, and methods. It is also mentioned in connection with its activities in endeavoring along with other national organizations to have established the quantity survey and payment for estimating in order to eliminate the loss through the duplication of estimating.

The report also finds that though standardization of dwellings has been tried and found rather impracticable, a great deal of loss is accounted for in lack of standardizing details of construction. Standardizing mill work, such as windows, doors, and other items entering into the average building, would, the committee believes, reduce the waste inherent in the "made-to-order" policy.

In the development of the building report approximately 106 builders and architects were consulted either personally or by correspondence. Two hundred and seventy-eight questionnaires, prepared especially for the building trades and designed to cover all items in the former questionnaires that applied to this industry, were given out and replies registered on 73 of these. Builders thus consulted were located all over the country, special attention being paid to representative cities such as New York, Boston, Philadelphia, Baltimore, Chicago, Cleveland, Atlanta, and San Francisco.

Building in New York State on the Increase

As reported by the various building departments of the principal cities of New York State and compiled by the bureau of statistics and information of the New York State Industrial Commission, the estimated cost of building work authorized in the first ten second-class cities of the state increased 46 per cent from April to May, making a gain of 65 per cent over the amount reported in the same month of 1920. The estimated value of building work authorized in May was $50,952,804 of which $45,417,308 was to be expended for the erection of new buildings. The gain in authorized building work in May was almost entirely in New York City, as only two up-state cities reported an increase during the month. The May increase in estimated value of building operations in New York City was 53 per cent, while the gains in the two up-state cities were 23 per cent in Buffalo and 604 per cent in Troy. The decreases in the remaining cities varied from 4 per cent in Albany to 49 per cent in Utica.

Division of Housing Begins Active Work

With the appointment of John M. Gries, of the Harvard School of Business Administration as the permanent head of the new division of housing created by Secretary of Commerce Hoover, the new Government agency is in a position to address itself immediately to its task of encouraging home building and home owning. The organization details of the division have been completed under the immediate direction of Franklin T. Miller, who resigned to undertake work outside of the department.

Before attempting to put emphasis upon any particular phase of the work, Prof. Gries expects to await returns from a questionnaire recently sent out. In a general way the division expects to give immediate attention to the matter of financing home-building projects. The question as to whether or not savings banks should apply a major portion of their deposits to home-building loans will be discussed with representatives of these banks.

Ten Proposed Projects Total More Than $20,000,000

During the past week or so *Engineering News-Record* has received news of the proposed construction of ten large projects which will entail the expenditure of more than $20,000,000. Most of the projects are miscellaneous buildings, though one of them is a hydroelectric development in Canada, which will cost when complete $3,000,000. The largest proposed contract is for the construction of college buildings for the Ellis College for Girls at Newtown Square, Pa., the total cost to be in the neighborhood of $5,000,000. The other projects are schools in Schenectady, $1,000,000; a hospital in Perrysburg, N. Y., $1,200,000; a hotel in Washington, Pa., $1,000,000; a hotel in Worcester, Mass., $1,000,000; extensions to Vanderbilt University, Nashville, Tenn., $4,000,000; the construction of exchanges for the Bell Telephone Co. at Montreal, $1,000,000; a bank and office building in Baltimore, $2,000,000, and a hotel at Cleveland, $1,000,000.

Unemployment Slightly Increased

According to the *Labor Market Bulletin* published monthly by the bureau of statistics and information of the New York State Industrial Commission, the May reports from state employment offices indicate a slight increase in unemployment over April. The ratio of workers seeking employment to each 100 places open which was 135 in April rose to 137 in May. The industries or occupations which show an increase in the proportion of persons looking for work to positions available are agriculture, building and construction, clerical work, domestic and personal service, hotel and restaurant work, and wholesale and retail trades.

Cement and Aggregate Production in 1921 Close to 1920

The approximate production of finished portland cement in the United States during the first six months of 1921 ending June 30, was 42,468,000 bbl., according to an estimate made by the United States Geological Survey. This production represents 94 per cent of the quantity made in the corresponding period of 1920 and over 42 per cent of the total production in 1920. The shipments during the first six months of 1921 were slightly in excess of 40,000,000 bbl., or about 98 per cent of the shipments for the first half of 1920 and 42 per cent of those for the whole year 1920. The stocks on hand, which amounted to more than 11,000,000 bbl., are slightly above normal, comparing with approximately 9,000,000 bbl. on June 30, 1920, and 8,941,046 bbl. on Dec. 31, 1920.

The statement of the Geological Survey is to the effect that the year 1921 began with mills producing at a moderate rate and shipments considerably less than production, but month by month both production and shipments of finished cement increased at a rapid rate, shipments exceeding production in May and June. Production in June was slightly greater than in June, 1920, and also a little above the average for that month during the last five years. The shipments in June of more than 10,500,000 bbl. were larger than those of any preceding June.

Aggregate Production

As to the production and shipments of aggregate, both the sand and gravel producers and the slag and crushed stone manufacturers have so far this year enjoyed a rather relatively high degree of activity. Slag has shown the lowest production as compared with 1920, the estimate made by the National Slag Association being that for the first six months of 1921, 1,250,000 tons of slag were produced as against 2,500,000 during the same period of 1920.

From figures supplied by the United States Geological Survey and the American Railway Association, the estimate is made by the National Association of Sand and Gravel producers that 23,305,950 tons of sand, gravel and crushed stone were shipped over the railroads during the first six months of 1921. These figures compare with 28,331,200 tons during the first half of the year of 1920 and with 31,823,340 tons shipped during the first six months of 1913. Records show that the 1921 shipments were 82 per cent of those of the 1920 figure and 74 per cent of the 1913 figure. The estimates given for 1913 and 1920 are based on 40 per cent of the production of sand and gravel and crushed stone reported for the entire year, as it is believed that 20 per cent more materials are shipped during the last six months of the year than during the first half. The estimate for 1921 is based on a report obtained from the American Railway Association, which shows that 466,117

cars were loaded with these materials up to July 1, the average loading being approximately 50 tons to the car.

Bids on Ohio Highway Projects Are 86 per Cent of Estimates

Bids opened by the Ohio Highway Commission on July 21 and 22 revealed the fact that the total low bid on the fifty-two projects was about 86 per cent of the engineer's estimate. The total estimate amounted to $3,406,697 and the total low bid $2,922,794. The work covers construction, reconstruction and repair of roads, grading, and drainage installation projects and the construction and repair of bridges. About 100 mi. of roads are to be repaired or constructed if all the contracts for which bids were asked are let.

Reduced Demand for Coal Cars Increases Car Surplus

Due principally to a reduction in the demand for coal cars in the Eastern district, an increase of 2,525 in the number of surplus cars during the seven-day period which ended on July 15, was shown by reports received from the rail carriers of the country by the car service division of the American Railway Association. The total number of surplus cars on that day was 372,050, compared with 369,525 on July 8.

Surplus coal cars on the latter date numbered 173,617, which was an increase of 12,011 within a week, while surplus box cars totaled 135,633, compared with 145,112 cars on July 8, or a decrease of 9,479 within that period. This increase was due largely to the increased demand for grain cars in the wheat sections.

In addition to the 372,050 surplus cars, reports just received by the car service division show that on July 1 there were also 354,611 freight cars out of repair, or 15.4 per cent of the cars on line. On June 15 there were 346,861 bad order cars, or 15.1 per cent of the cars on line.

Production of Western Lumber

For the week ending July 16, 107 mills in western Oregon and western Washington report lumber production at 49,852,574 ft. b.m., which is 35 per cent below normal. New business totaled 44,998,272 ft. b.m., and shipments totaled 46,592,018 ft. b.m.

Weekly Construction Market

THIS limited price list is published weekly for the purpose of giving current prices on the principal construction materials, and of noting important price changes on the less important materials. Moreover, only the chief cities are quoted.

The first issue of each month carries complete quotations for all construction materials and for the important cities. The last complete list will be found in the issue of July 7, the next, on August 4.

Steel Products:	New York	Atlanta	Dallas	Chicago	Minneapolis	Denver	San Francisco	Seattle	Montreal
Structural shapes, 100 lb	$3.03	$4.00	$4.30	+$3.03	$3.31	$4.65	$4.25	—$4.10	$5.00
Structural rivets, 100 lb	4.40	5.25	5.75	—4.03	5.20	5.50	5.80	5.50	8.50
Reinforcing bars, ¾ in. and larger, 100 lb	2.93	3.25	3.75	—2.93	3.53½	4.02½	2.35	4.00	4.25
Steel pipe, black, 3½ to 6 in. lap, discount	51%	—52.65-5%	45%	58½%	53.9-5%	36%	49.80%	47½%	5%
Cast-iron pipe, 6 in. and over, ton	49.10	—43.33	57.50	49.10	57.80	62.00	80.00	—63.00	75.00
Concreting Material:									
Cement without bags, bbl	2.60@2.70(del.)	+2.75	2.80	2.17	—2.41	3.10	3.09	3.10	2.75
Gravel, ¾ in., cu.yd	2.25	—2.25	3.00	2.25	2.00	2.50	2.25	1.50	1.50
Sand, cu.yd	1.25	—1.35	2.50	2.25	1.00	1.10	1.50	1.50	1.25
Crushed stone, ¾ in., cu.yd	1.90 to 2.00	2.25	2.80	2.50	2.25	3.50	2.25	3.50	2.10
Miscellaneous:									
Pine, 3x12 to 12x12, 20 ft. and under, M.ft	47.00	38.00	35.00	55.00	—35.00	47.00	27.00	—22.00	120.00
Lime, finishing, hydrated, ton	—16.49	—19.00	25.00	20.00	29.00	32.00	25.40	24.00	28.00
Lime common, lump, per bbl	3.79	+1.50	2.75	1.65	1.50	3.10	2.25	2.75	15.00
Common brick, delivered, 1,000	18.40	—10.00	12.65	12.00	17.00	14.00	18.00	14.00	18.00
Hollow building tile, 4x12x12, block	Not used	.14	.13	.09475	.092	.09	.12½	.11	.15
Hollow partition tile 4x12x12, block	.1232	—.14	.13	.07410	.092	.10	.14½	.12	.....
Linseed oil, raw, 5 bbl. lots, gal	+.80	+.85	.97	+.87	+.91	.96	.96	.79	.84
Common Labor:									
Common labor, union, hour	.75@.80	.35	.....	1.00	50	.50@.63½	.81¼	.75	.....
Common labor, non-union, hour	.....	.25	.35@.45	—.40	50	.37½@.50	.50@.55	.50	.30

Explanation of Prices—Prices are to contractors in carload lots unless other quantities are specified. Increases or decreases from previous quotations are indicated by + or — signs. For steel pipe, the prevailing discount from list price is given: 45-5% means a discount of 45 and 5 per cent, 45@50 means a range of 45 to 50 per cent. Charge of 15c. per 100 lb. for cutting reinforced steel into 2-ft lengths or over. **New York** quotations are delivered except tiles, which are "on trucks." Common lump lime per 300-lb. bbl.; both lump and hydrated quoted alongside dock. Sand gravel and crushed stone are quoted alongside dock. **Chicago** quotes hydrated lime in 50-lb paper bags. **Minneapolis** quotes on fir instead of pine. Brick and hollow tile delivered. Cement on cars; $2.60 delivered. Gravel, sand and crushed stone quote at pit. We quote on brown lime; white is 15c. additional. Common labor not organized. **Denver** quotes cement "on tracks"; gravel and sand at pit, stone on cars, lime, brick, hollow tile and lumber on job. Tile price is at warehouse. Linseed oil, delivered. **Atlanta** quotes sand, stone and gravel per ton instead of cu.yd. **Dallas** quotes lime by the 180-lb. bbl. Steel and crushed stone are quoted f.o.b. cars, other materials delivered. **San Francisco** quotes on Heath tile, 5½ x 8 x 11½. Prices are all f.o.b. warehouses except C. I. pipe, which is mill price plus freight to railway depot at any terminal. Lumber prices are delivered "at ship tackle in San Francisco ex mill." **Seattle** quotes on Douglas fir instead of pine; and on lime in paper bags. **Montreal** quotes sand stone, gravel and lump lime per ton. Cement, lime and tile are delivered; sand, gravel and stone, on siding; brick f.o.b. plant; steel and pipe at warehouse. Cement price is in Canadian funds, exchange with the United States being 14 per cent at present. Bag change is 80c. per bbl. Discount of 10c. per bbl. for payment within 20 days from date of shipment.

Changes Since Last Week

The cement situation in New York is unchanged since our last report; demand is small, awaiting lower prices by the manufacturers. We quote cement in Atlanta 25c. higher than last week. The Canada Cement Co., Montreal, advises us that there has been a price change in Montreal, the first in a year, the price being $2.75 per bbl., net, with 10c. off for payment within 20 days of shipment. In considering Canadian prices the exchange rate must be kept in mind, to-day's rate being 14 per cent.

The steel market remains dull, with demand awaiting more favorable quotations. It should not be overlooked, however, that steel is relatively cheaper than are concreting materials. Warehouse prices are the same in New York and Chicago, $3.03 for shapes, $2.93 for reinforcing bars. Cast-iron pipe is $43.33 in Atlanta, as against $59.22, and Seattle reports a $2 decrease.

Common lump lime in Atlanta has advanced from $1.45 per 180-lb. bbl. to $1.50, although strangely enough hydrated lime is lower.

Fir is down $1 in both Minneapolis and Seattle. The price of linseed oil is again rising throughout the country.

Non-union common labor is down 5c. per hour, in Chicago, being now obtainable at 40c.